

# TIROS VII RADIATION DATA CATALOG AND USERS' MANUAL

Volume 1

(June 19, 1963 - September 30, 1963)

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**TIROS VII  
RADIATION DATA CATALOG  
AND  
USERS' MANUAL**

**VOLUME I  
JUNE 19, 1963 – SEPTEMBER 30, 1963**

**By  
Staff Members  
of the  
Aeronomy and Meteorology Division  
Goddard Space Flight Center  
National Aeronautics and Space Administration**

**September 30, 1964**

## FOREWORD

This combination Catalog and Users' Manual follows the same documentation format for the TIROS VII five-channel medium resolution scanning radiometer experiment that was used for the TIROS IV experiment. It replaces the two separate companion volumes which were published previously for TIROS II and TIROS III. The quantity of radiation data already acquired from TIROS VII exceeds several times over the total quantity acquired from any of the previous TIROS radiation experiments, and as of this writing data are still being acquired from TIROS VII. As a result, the TIROS VII Catalog-Manual will be published in several separate volumes. This, the first volume, contains general discussions about the nature of the experiment, the calibration, and the processing of data, in addition to specific information concerning the data acquired during the period from launch on June 19, 1963 to September 30, 1963. The corresponding specific information concerning data acquired after September 30, 1963, will be found in succeeding volumes.

In this Volume of the TIROS VII Catalog-Manual, the radiometer and its calibration, the data processing, the "Final Meteorological Radiation Tape", the observed radiometer response behavior patterns, and possible corrections are discussed. This Volume also includes, in two forms, documentation of each orbit of successfully reduced radiation data acquired from launch, June 19, 1963, to September 30, 1963. One method of presentation is the Index of Final Meteorological Radiation Tapes and the other is a Subpoint Track Summary of Available Radiation Data in diagrammatic form.

Many members of the staff of the Aeronomy and Meteorology Division contributed to the success of the TIROS VII medium resolution radiometer experiment. Valuable contributions in the area of computer programming for data processing came from the National Weather Satellite Center, U. S. Weather Bureau, whose efforts are gratefully acknowledged.

The task of assembling the information contained in this manual into written form suitable for publication was largely accomplished by the following members of the Aeronomy and Meteorology Division:

Mr. George Nicholas, Editor  
Miss Musa Halev, Co-editor  
Mr. W. R. Bandeen  
Mr. Robert Hite  
Mr. Andrew McCullough  
Mr. Harold Thompson  
Mr. Frederick Woolfall

The efforts of these individuals are hereby acknowledged.

The preparation of the material presented in Appendix B was accomplished mainly through the effort of Mr. Eldon Bowman.

## ABSTRACT

The TIROS VII Meteorological Satellite contains a medium resolution scanning radiometer. Two of the channels of this instrument are sensitive to reflected solar radiation and the other three respond to emitted thermal radiation from the earth and its atmosphere. Channel 1 of TIROS VII is sensitive within the  $15\mu$  carbon dioxide region and replaces the  $6.0\text{-}6.5\mu$ , water vapor channel of TIROS II, III, and IV. The three thermal channels are calibrated in terms of equivalent blackbody temperatures, and the reflected solar radiation channels in terms of effective radiant emittances. The calibration data, along with orbital and attitude data, and the radiation data from the satellite were incorporated in a computer program for an IBM 7094 which was used to produce, in binary form, the "Final Meteorological Radiation Tape" which is the basic repository of all radiation data.

Before work with the TIROS VII radiation data is attempted, an understanding of the radiometer, its calibration, and the problems encountered in the experiment, especially from the radiometer response behavior, is essential. The instrumental design, development work, and the calibrations herein described were performed by the Goddard Space Flight Center staff, whereas the computer and programming efforts were carried out jointly by the staffs of the National Weather Satellite Center, U. S. Weather Bureau, and the Goddard Space Flight Center.



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## LIST OF COMMON SYMBOLS

- A Albedo, assumed to be equal to  $\bar{W}/\bar{W}^* \cos \Theta_0$
- $A^i$  Quasi-global albedo at orbit  $i$ , taken from a smoothed curve through a large number of measurements. It is assumed that the downward trend of the smoothed curve is due solely to instrumental degradation
- $A_\lambda$  Spectral Absorptivity of the thermistor detector
- $D$  Digital Number: scale 0 to 127
- $F$  Number of cycles-per-second above the base frequency of a given 50 cps subcarrier band
- $\Delta F$  The flight measured space-viewed level (both directions viewing outer space) minus the ground-calibrated "space-viewed" level (both directions viewing blackbodies of liquid nitrogen temperatures ( $-196^\circ\text{C}$ )) in terms of cycles-per-second of a given 50 cps subcarrier band
- $F_{sc}$  Output frequency of the voltage controlled oscillator
- $J_\lambda$  Spectral radiant intensity of visible light source, i.e., a standard tungsten lamp or the sun (watts/steradian/micron)

$R_{\lambda}^B$	Spectral reflectivity of the black half of the chopper disk
$R_{\lambda}^M$	Spectral reflectivity of the aluminized half of the chopper disk
$R_{\lambda}^P$	Spectral reflectivity of the radiometer prism
$R$	Distance from the visible light source to the center of the diffuse reflector
$T_{BB}$	Equivalent blackbody temperature (degrees Kelvin)
$T_C$	Radiometer housing temperature
$T_E$	Satellite electronics temperature
$T_V$	Television system clock number 2 temperature
$V_{RAD}$	Output voltage of the radiometer
$W$	Total outgoing longwave flux (watts/meter <sup>2</sup> )
$W_{\lambda}(T)$	Spectral radiant emittance (the Planck function) for a blackbody of temperature $T$ (watts/meter <sup>2</sup> /micron)
$\overline{W}$	Effective radiant emittance (watts/meter <sup>2</sup> )—defined by equation (2) for channels 1, 2, and 4, and defined by equation (5) for channels 3 and 5
$\overline{W}_{ave}^i$	Average quasi-global effective radiant emittance at orbit $i$ , taken from a smoothed curve through a large number of measurements. It is assumed that the downward trend of the smoothed curve is due solely to instrumental degradation
$\overline{W}^*$	The effective solar constant, defined by equation (6)
$f_{\lambda}$	Spectral transmission of the filter-lens combination
$k$	Slope of $F_{sc}$ vs. $\overline{W}$ transfer function
$r_{\lambda}$	Spectral reflectivity of the diffuse reflector employed in the calibration of the reflected solar radiation channels
$\Delta\phi$	Right ascension of the sun minus the right ascension of the orbital ascending node
$\Omega$	Solid angle of the sun as viewed from the earth
$\gamma$	Incidence angle of radiation from visible light source impinging upon diffuse reflector employed in the calibration of the visible channels
$\delta T_{BB}$	Thermal channel temperature correction resulting from instrumental degradation
$\Theta$	Zenith angle
$\kappa^i$	Degradation parameter at orbit $i$ in equations (7) and (8)
$\lambda$	Wavelength in microns
$\rho^i$	Degradation parameter at orbit $i$ in equation (7)
$\phi_{\lambda}$	Effective spectral response of the radiometer defined by equation (1)

Subscript:

- ave* Average  
 $\odot$  Sun

Superscripts:

- <sup>'</sup> Indicates a measurement or other value which may be affected by instrumental degradation  
<sup>*i*</sup> Orbit number

## I. INTRODUCTION

The TIROS VII Meteorological Satellite was injected into orbit on June 19, 1963. Its mean orbital characteristics are listed in Table I.

TABLE I

Perigee Altitude -----	622 km
Apogee Altitude -----	648 km
Anomalistic Period -----	97.42 minutes
Inclination -----	58.2°

The experiments flown in the satellite include two television cameras, two radiometers, and an electron temperature probe experiment. The radiometers measure emitted thermal and reflected solar radiation from the earth and its atmosphere. One radiometer is the University of Wisconsin's heat balance experiment.

This manual is concerned only with the second radiation measuring device, a five-channel medium resolution scanning radiometer, which responds to radiation in five different spectral regions. Three of these channels respond to emitted thermal radiation from the earth and its atmosphere, and the other two channels respond to reflected solar radiation. One of the thermal radiation channels responds to the  $15\mu$  carbon dioxide band and replaces the  $6.0\mu$ - $6.5\mu$  "water vapor absorption" channel of the radiometers flown on TIROS II, TIROS III, and TIROS IV. The three thermal radiation channels are calibrated in terms of equivalent blackbody temperatures and the reflected solar radiation channels in terms of effective radiant emittances.

The radiation data from the medium resolution radiometer experiment are processed together with attitude information and calibration data on an IBM 7094 computer to produce a binary "Final Meteorological Radiation (FMR) Tape," which is the basic repository of the radiation data in terms of equivalent blackbody temperature or effective radiant emittance.

Before attempting to interpret the radiation data from TIROS VII which are contained on the FMR tapes, careful consideration should be given to all points discussed

in this manual. An understanding of the significance of the equivalent blackbody temperatures or effective radiant emittance values and a familiarity with the principles of the radiometer, its peculiarities, and the method of calibration are essential. Before attempting to utilize the radiation data, the effects of calibration degradation on the data must also be considered.

This combination Catalog and Users' Manual follows the same documentation format as that used for the TIROS IV Radiation Data Catalog and Users' Manual,<sup>1</sup> replacing the two separate volumes which were published for the TIROS II and TIROS III five-channel radiometer experiments.<sup>2,3,4,5</sup> At this writing TIROS VII has successfully returned radiation data for over one year, being almost three times as long as the useful lifetimes of any of the previous scanning radiometer experiments. This large quantity of information has, thus, necessitated publishing the TIROS VII Catalog-Manual in several volumes. This, the first volume, discusses the radiometer and its calibration, the data processing, the "Final Meteorological Radiation Tape," the observed behavior of the radiometer responses, and possible corrections to the data due to the degradation of the instrumental response. This volume also includes, in two forms, documentation of each orbit of successfully reduced radiation data acquired from launch, June 19, 1963, to September 30, 1963. One form is an Index of all FMR tapes; the other is a diagrammatic Subpoint Track Summary of the available radiation data for each orbit. Future volumes will include information concerning the radiometer response behavior and general developments of the experiment along with an Index and a Subpoint Track Summary covering subsequent time periods.

The radiation data are available in various "hard copy" formats suitable for presenting limited portions of the data, as well as, the "binary" FMR tape format, suitable for computer processing and containing the originally reduced data in their entirety. The data are reduced to the FMR Tape format by the experimenters at the following address:

TIROS Radiation Data, Code 651  
Aeronomy and Meteorology Division  
NASA, Goddard Space Flight Center  
Greenbelt, Maryland 20771

Duplicates of the FMR Tapes are archived at the following data center:

National Weather Records Center  
U. S. Weather Bureau  
Federal Building  
Asheville, North Carolina 28801

Copies of the data in the various standard formats listed below can be obtained for production costs by writing to the National Weather Records Center (NWRC). Unless otherwise requested, the NWRC will routinely provide cost estimates prior to filling orders. *In addition, limited quantities of the data in the standard formats may be obtained by investigators without charge by writing to the Goddard Space Flight Center (GSFC) experimenters.* Detailed descriptions of most of these formats are contained in the TIROS II and TIROS III Radiation Data Catalogs<sup>2,4</sup> and in the various Radiation Data Users' manuals.<sup>1,3,5</sup> These publications should be consulted before orders are placed. Some flexibility in the machine programs is possible, and users having requirements which cannot be satisfied by the available standard formats should write to either of the above addresses for further information.

The data are presently available in the following standard formats:

**A. Copies of Final Meteorological Radiation (FMR) Tapes (binary)**

The FMR Tape is the product of a computer program whose input is the attitude/orbital data, digitized radiation data, and the TIROS radiometer calibration package. These tapes are usable only on IBM compatible electronic data processing equipment having a core storage capacity of the equivalent of at least 4096 36-bit words.

NWRC Price (including tape) \$60 per reel  
or, if user provides tape \$30 per reel

**B. Data Listings (Program MS 500)**

Machine programs are available which will produce a printed list of the calibrated in-

formation for a specified time period from all five sensors together with appropriate locator information (see Section IX of the TIROS III Catalog<sup>4</sup>). The NWRC cost for the listings is dependent upon the size of the sample and its position within the tape data files. For example, a listing of 10 minutes of satellite data (about 100 swaths with 50 samples per swath which would cover an area the size of U.S.) would cost about \$20 to \$30.

**C. Grid Print Maps**

A series of programs produce printed and contoured data referenced to a square mesh grid on polar stereographic or Mercator map bases. Grid print maps may be produced for either a single orbit (see Section IV of the TIROS II Catalog<sup>2</sup> and Sections V, VI, VII, and VIII of the TIROS III Catalog<sup>4</sup>) or a composite of several orbits (see Section IX of the TIROS III Catalog<sup>4</sup>). The following standard options are available and should be specified when requesting grid print maps:

**1. Map and Approximate Scale**

- a. Polar Stereographic, 1/30 million (approx.) (AW950)
- b. Polar Stereographic, 1/10 million (approx.) (MS501)
- c. Multi-Resolution Mercator (MSC 2)
  - (1) 5.0 degrees Long. per mesh interval—1/40 million (approx.)
  - (2) 2.5 degrees Long. per mesh interval—1/20 million (approx.)
  - (3) 1.25 degrees Long. per mesh interval—1/10 million (approx.)

**2. Maximum Sensor Nadir Angle** (unless otherwise specified, 58° will be used)

**3. Field Values and Contouring** (unless otherwise specified, all maps will include field values and contouring except Mercator Maps of scales larger than 1/20 million which will contain no field values or contouring (see Section IV of the TIROS III Catalog<sup>4</sup>).

A data population map, indicating the number of individual measurements con-

tained in each grid point average, as well as a sample latitude-longitude overlay for geographically locating the data, will ordinarily be provided along with each grid print map.

The NWRC cost for grid print maps will vary, of course, according to the option selected. To illustrate, for a Mercator (60°N-60°S) grid print map, involving one sensor and one orbit, the cost would be about \$25 to \$35.

When ordering "hard copy" data, the following identifying information should be given:

1. Satellite (e.g. TIROS VII)
2. Read-Out Orbit No. (cf. Index of FMR Tapes in Appendix A)
3. Channel No. (e.g. Channel 2, 8.0-12.0 microns; Channel 3, 0.2-6.0 microns; etc.)
4. Calendar Date of Equator Crossing (cf. Index of FMR Tapes in Appendix A)
5. Beginning and Ending Times of Data in GMT (cf. Index of FMR Tapes and Subpoint Track Summary in Appendix A and Appendix B)
6. Format Desired

When ordering FMR Tapes, only items 1 and 2 above need be given, plus:

7. FMR Tape Reel No.(s) (cf. Index of FMR Tapes, Appendix A)

Television pictures taken concurrently with the radiation data may also be obtained from the National Weather Records Center. The availability of such pictures is documented in the Key to Meteorological Records Documentation No. 5.37, "Catalog to Meteorological Satellite Data-TIROS VII Television Cloud Photography", copies of which may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

## II. DESCRIPTION OF THE MEDIUM RESOLUTION RADIOMETER EXPERIMENT

### 2.1 *Principle of the Radiometer*

The principle of the radiometer is illustrated in Figure 1 which shows the compo-

nents of a single channel. The fields of view of the channels are approximately coincident, each being about five degrees wide at the half-power point of the response. The optical axis of each channel is bi-directional, 180° apart. As the half-aluminized, half-black chopper disk rotates, radiation from first one direction and then the other reaches the thermistor bolometer detector. This results in a chopped output which is amplified and rectified, giving a DC signal which (neglecting electronic noise and possible optical imbalance) is theoretically proportional to the difference in energy flux viewed in the two directions. Variations in the amplitude of the radiometer signal are converted into sub-carrier frequency deviations and stored by means of a miniature magnetic tape recorder. When the satellite is interrogated, while within range of a Command and Data Acquisition Station, the information is telemetered to the earth where it is recorded on magnetic tape. The further processing of these magnetic tapes is discussed in Section IV of this manual.

The radiometer is mounted in the satellite such that the optical axes are inclined 45° to the satellite spin axis. (The viewing directions are designated "wall" and "floor" according to their orientation in the satellite.) When one optic views the earth, the other views outer space. The outer space radiation level (assumed to be zero) is used as a reference. When both optics are viewing outer space, the resultant signal is designated as the "space-viewed level." Theoretically, this signal should be zero, but in reality is not, due to electronic noise and any initial optical imbalance, plus subsequent changes in balance caused by the degradation of certain channels after the laboratory calibration.

As the satellite rotates on its axis, the radiometer scan pattern on the surface of the earth is defined by the intersection of a 45° half-angle cone and a sphere. This pattern ranges from a circle when the spin vector is parallel to the orbital radius vector, to two hyperbola-like branches when the spin vector is perpendicular to the radius vector. The orbital motion of the satellite provides



the scan advance. When viewing vertically downward from a height of about 635 km, the spatial resolution of the radiometer is about 55 km; i.e., the "spot" on earth viewed by the radiometer has a diameter of 55 km.

## 2.2 Description of the Sensors

The nominal channel bandwidths for the TIROS VII medium resolution radiometer are given in Table II.

TABLE II

Channel	Nominal Bandwidth (Microns)	Nature of Band
1	14.8 -15.5	carbon dioxide absorption
2	8.0 -12.0	atmospheric window
3	0.2 - 6.0	reflected solar radiation
4	8.0 -30.0	thermal radiation from the earth and atmosphere
5	0.55- 0.75	response of the TV system

In the 14.8 to 15.5 micron channel a maximum absorption due to carbon dioxide is encountered. Energy in this channel is received mainly from the vicinity of 15 to 35 kilometers. Regions below 10 and above 40 kilometers contribute only very little to the radiance at normal incidence; however, when regions near the horizon are within the field of view of the sensor, the center of mass of the emission function shifts upward to higher altitudes and warmer temperatures; hence, limb-brightening occurs. The radiance for this channel can be interpreted in terms of mean stratospheric temperatures, weighted over varying altitudes, depending upon atmospheric structure and sensor viewing angle; however, the radiance is virtually independent of the state of cloudiness of the atmosphere; and is, therefore, not correlated to the other channels.<sup>8, 9, 10</sup> The energy received in the 8.0 to 12.0 micron channel originates mainly from either the earth's surface and/or clouds since absorption due to any of the atmospheric constituents—except ozone which covers only a minor portion of this channel—is every small. The total solar energy reflected from the earth and its atmosphere is contained in the 0.2 to 6.0 micron channel. The 8.0 to 30.0 micron channel radiation includes a substantial contribution by the 8-12 micron region. The emission over

the remainder of the 8-30 micron region is primarily from the carbon dioxide and rotational water vapor absorption bands, and the radiance at the top of the atmosphere in these bands originates mostly in the atmosphere and thus represents lower temperatures than those detected by the 8-12 micron channel. The 0.55 to 0.75 micron channel covers the maximum of the solar energy distribution and is similar in its spectral response to the TV cameras on the satellite.

The interpretation of the radiation data in terms of physically significant qualities has been given in the literature.<sup>10-38</sup>

## 2.3 Geographic Limitations of Data Utilization

Care should be exercised in the use of the correlation of the radiation data with geographic locations, such as attempted comparison with synoptic situations. Uncertainties in attitude lead to an estimated error of 1° to 2° in great circle arc. At a nadir angle of zero, a 2° error would result in a position error on the earth's surface of less than 20 miles, while a 2° error for a nadir angle of 60° corresponds to an error of over 200 miles. It should be emphasized that such errors result in distortions as well as translations, and a simple linear shift of the data is in general not sufficient for correction.<sup>39-44</sup>

In addition to attitude errors, time errors also contribute to difficulties in geographic correlation.<sup>39</sup> The principal sources of time errors are: mistakes at the ground station in transmission of the end-of-tape pulse, erroneous sensing by the analog-to-digital converter of the end-of-tape pulse, and the necessity of counting through noise on the relative satellite clock frequency. These errors are generally estimated to be less than ten seconds in TIROS VII. However, users are cautioned to be watchful for those rare cases where there still might be larger errors of the order of one minute or more. Time errors also result in distortions as well as translations.

## III. CALIBRATION

Before considering the calibration flow

sequence, it is necessary to discuss two quantities which are fundamental to the calibration. These are the effective spectral response and the effective radiant emittance.

### 3.1 Effective Spectral Response

The radiation received by the radiometer is modified by the various elements in the optical train before being absorbed by the bolometer detector. These include the reflecting properties of the prism and chopper, and the transmission characteristics of the filters and lenses. By assuming equal optical properties and temperatures for both sides of the prism, an effective spectral response,  $\phi_\lambda$ , can be defined as

$$\phi_\lambda = R_\lambda^p (R_\lambda^m - R_\lambda^s) f_\lambda A_\lambda \quad (1)$$

The various optical elements in each channel were evaluated as to reflectance or transmittance using combinations of three commercial spectrophotometers. Combined, these instruments cover the wavelength range of 0.25–35 microns. All three units can be used for either transmittance or reflectance measurements. The Beckman DK-2 using an  $\text{SiO}_2$  prism operates through the region of 0.25–2.5 microns. A  $\text{MgO}$  coated integrating sphere reflectance attachment yielding either total or diffuse reflectance of a sample for energy incident at an angle of approximately  $5^\circ$  may be employed with this device. The two infrared instruments, the Beckman IR-5 and IR-5A, use rock salt and cesium bromide respectively as prism materials to cover the region of 2.0–35 microns with an overlap at 11–15 microns. Reflectance measurements here are performed using attachments that are inserted in the reference and sample beam.

These give specular reflectance only, and the beam is at an angle of incidence of  $30^\circ$  to the sample.

The materials used in the lenses and filters of each channel are given in Table III.

All of the terms in Equation 1 for each channel of the TIROS VII radiometer were taken from Barnes Engineering Company measurements. A discussion of the terms from which  $\phi_\lambda$  is derived follows.

#### *Spectral Reflectivity of the Radiometer*

#### *Prism, $R_\lambda^p$*

Total reflectance measurements of the prism relative to a standard (freshly burned magnesium oxide) for a  $5^\circ$  angle of incidence are made. The measurements in the visible portion of the spectrum up to 2.5 microns are performed on both surfaces of the prism and over different areas of each side to check the uniformity of reflectance. The measurements in the infrared consists of comparing the spectral reflectance for a  $30^\circ$  angle of incidence of the sample to a reference beam of infrared transmittance through air. The reference level is normalized to 100% with a standard silicon monoxide coated aluminized mirror.

#### *Spectral Reflectivity of the Radiometer Chopper, $(R_\lambda^m - R_\lambda^s)$*

Spectral reflectance of both the black (absorptive) and aluminized (reflective) surfaces of the chopper are measured independently. In the visible portion of the spectrum the aluminized surface measurements are performed in the same manner as the reflectance measurements of the prism. The 100% line is adjusted using magnesium oxide in the reference and sample holders. Then the aluminized surface is placed in the sample part and the reflectance of the sample is compared to the reflectance of the magnesium oxide. Because of the great difference in the reflectances of the two halves of the chopper face and the fact that the reflectance of the black absorbing surface is low, a technique was established to determine the amount of energy that is reflected from the black surface only. A second measurement is performed with the same equipment setup, but with the absorptive sample removed from the holder. This is a measure of the relative amount of energy which is collected by the detector but not contributed by the sample surface. The actual reflectance is obtained by subtracting the relative transmittance due to the instrument construction from the black surface measurement.

In the infrared region the measurement is identical to the prism reflectance measurement for the reflective and absorptive surfaces.

### *Spectral Transmission of the Filter-Lens Combination in the Radiometer, $f_\lambda$*

Spectral transmittance measurements are performed on all lens materials using the same Beckman spectrophotometers. In the visible and near-infrared portions of the spectrum, the Beckman DK-2 spectrophotometer is used with air as the reference. The 100% line is set with air versus air. Then the measurement is performed to provide the relative transmittance of the lens material to that of air. Plane parallel samples, equivalent in thickness to that of the lenses, are measured with the instrument. Measuring this equivalent sample (having the same mean thickness as the lens used in the system) is an accepted measurement technique. This method is used because measurements of the lenses themselves would produce errors due to lens curvature.

Spectral transmittance of the filters is performed in the same manner used to measure the lenses. Measurements are performed using air as the reference for comparative energy transmission measurements. The 100% line is adjusted using air versus air to detect any difference between the two paths before a test is run using the sample versus air.

### *Spectral Absorptivity of the Thermistor Detector, $A_\lambda$*

The spectral absorptivity of the thermistor detector is measured by irradiating the detector with a fixed amount of monochromatic energy at each successive wavelength increment over the spectrum from the ultraviolet to the far infrared. The test setup contains a source radiating energy in the portion of the spectrum being investigated.

Two detectors are used—one is the reference and the second is the detector under test. Monochromatic energy is directed to the reference cell first and the energy onto the detector is adjusted until the same amount of energy is obtained at each wavelength increment. Because the reference cell response is assumed to be spectrally flat, the energy is adjusted until the same voltmeter reading is obtained. Then the voltmeter

readings are plotted as a relative spectral response normalized to 100% at the highest level.

Tables IV through VIII and Figures 2 through 6 give the effective spectral response for each of the channels of the TIROS VII radiometer.

### *3.2 Effective Radiant Emittance*

The preflight calibration of the three emitted thermal radiation channels (channels 1, 2, and 4) was carried out by simulating the space-referenced earth signal in the laboratory. The TIROS VII radiometer and its associated electronics were calibrated as a system. The radiometer's field of view was filled in one direction by a blackbody target at liquid nitrogen temperature (80°K)—which is essentially equivalent to the space reference—while the field of view in the other direction was filled with a blackbody target whose temperature varied over the range expected when viewing the earth and its atmosphere. Thus, the infrared measurements are in terms of an "equivalent temperature,  $T_{nn}$ ," of a blackbody filling the field of view which would cause the same response from the radiometer. Since the spectral response of the radiometer is assumed to be known from the spectral characteristics of the individual reflecting, refracting, and transmitting components of the optics, that portion of the radiant emittance of any source that falls within the spectral response curve of the instrument can be calculated. This quantity is defined as the effective radiant emittance,  $\bar{W}$  ( $\frac{\text{watts}}{\text{meter}^2}$ ) and can be written as

$$\bar{W} = \int_0^\infty W_\lambda (T_{nn}) \phi_\lambda d\lambda. \quad (2)$$

The data from the three channels, which detect emitted thermal radiation, can, therefore, be expressed either as  $T_{nn}$ , in degrees Kelvin, or as  $\bar{W}$ , in watts per square meter, of radiant emittance within the spectral response curve of the channel. The  $\bar{W}$  vs.  $T_{nn}$  function for channels 1, 2, and 4 are given in Tables IX, X, and XI and in Figures 7, 8, and 9.

In calibrating the two channels which de-

fect reflected solar radiation (channels 3 and 5) one direction of the channels was merely masked with black tape to simulate space. To simulate reflected solar radiation from the earth and its atmosphere, a white diffuse reflector of known spectral reflectivity was illuminated at normal incidence from a standard lamp of known spectral intensity at a measured distance away. From these parameters the spectral radiant emittance from the reflecting surface was determined. With the illuminated reflector filling the field of view, the output signal from each channel is measured. The spectral radiant emittance from the reflector is integrated over the spectral response curves of the solar channels to yield that portion of the radiation viewed to which each channel responds. The result of such integration is the "effective radiant emittance,  $\bar{W}$ ". Thus, the reflected solar radiation measurements are in terms of that portion of diffuse radiation,  $\bar{W}$ , from a target filling the field of view, to which each channel responds. In order to interpret these measurements in terms of reflectance (loosely, "albedo") one must know the effective radiant emittance,  $\bar{W}^*$ , which would be measured by each channel if the field of view were filled by a perfectly diffuse surface of unit reflectivity when illuminated by one solar constant at normal incidence. The expressions for  $\bar{W}$  and  $\bar{W}^*$  for channels 3 and 5 are defined in Section 3.6.2.

### 3.3 Radiation Data Flow Sequence

The radiation data flow sequence is shown in Figure 10. The sequence from satellite through ground station is illustrated in Figure 10(a). When an effective radiant emittance  $\bar{W}$  is viewed by one side of the radiometer while the other side views outer space, and with a radiometer housing temperature,  $T_c$ , a radiometer output voltage,  $V_{RAD}$  is obtained. This relationship  $V_{RAD} = f(\bar{W}, \text{SIDE}, T_c)$  is shown schematically in Figure 10(b). The signal,  $V_{RAD}$ , is fed into a voltage controlled oscillator which produces an output frequency,  $F_{sc}$ , when the oscillator electronics temperature is  $T_E$ . This relationship,  $F_{sc} = f(V_{RAD}, T_E)$ , is shown schematically in Figure 10(c), and is given in Figures 11-

15 for channels 1, 2, 3, 4, and 5.

At the ground station, the frequency,  $F_{sc}$ , now increased by a factor of 30, is fed into a demodulator, the output of which enters an analog-to-digital converter which converts  $F_{sc}$  to a digital number,  $D$ . The conversion formula is

$$D = \frac{127}{50} F_{sc} \quad (3)$$

and is shown schematically in Figure 10(d). The resulting digital number,  $D$ , and the temperatures,  $T_E$  and  $T_c$ , which are also telemetered from the satellite, are used to obtain the value  $\bar{W}$  (or  $T_{RH}$ ) for channels 1, 2, and 4 and the value  $\bar{W}$  for channels 3 and 5 from the calibration data as indicated below.

In practice, for the purpose of simplifying the data reduction, each channel is calibrated for different values of  $T_c$  while maintaining a fixed relationship between  $T_E$  and  $T_c$  rather than calibrating the radiometer and each oscillator as separate units to obtain the transfer functions shown in Figures 10(b) and 10(c). In addition, each oscillator is calibrated as a function of  $T_E$  to obtain the transfer function as shown in Figure 10(c).

### 3.4 Relation Between Electronics, Radiometer Housing, and TV Clock No. 2 Temperatures

The calibration of the TIROS VII radiometer-oscillator system was corrected according to the equation

$$T_E = T_c + 10^\circ\text{C} \quad (4)$$

This was necessary because during flight a  $10^\circ\text{C}$  difference between electronics and radiometer housing temperatures was present. The TIROS VII calibration curves, which are presented in this manual, therefore, include this correction.

The validity of the TIROS VII calibration with regard to equation (4) was checked using the flight data for  $T_E$  and  $T_c$  through orbit 1276. After orbit 1276 the channel which provides for the telemetry of  $T_E$  and  $T_c$  did not function. The comparison of  $T_E$  and  $T_c$  to orbit 1276 is shown in Figure 16(b); it can be seen that there is some variation of  $T_E$  and  $T_c$  from equation (4)

and the maximum is  $7^{\circ}\text{C}$ . The effect on  $T_{RH}$  or  $\bar{W}$  for each channel of a  $7^{\circ}\text{C}$  temperature difference from the calibrated  $T_E$  and  $T_C$  relationship is given in Table XII. The maximum  $T_{RH}$  difference in the thermal radiation channels occurs for channel 1 and is  $1^{\circ}\text{C}$  while the maximum difference in  $\bar{W}$  for the reflected solar radiation channels, in percent of one solar constant radiated from a diffuse source, is 0.4%.

After orbit 1276,  $T_C$  was derived from one of the television systems carried on the satellite, namely from the TV clock No. 2 temperature,  $T_V$ . The TV clock No. 2 is located almost diametrically opposite from the radiometer housing and 11.5 inches from the center of the satellite. A very good relationship can be established between  $T_V$  and  $T_C$  before orbit 1276, and from this relationship  $T_C$  can be derived from  $T_V$  after orbit 1276. The difference between  $T_V$  and  $T_C$  is not constant but is a function of both the total amount of time during one orbital period and the time prior to readout that the satellite is exposed to the sun or in the earth's shadow.  $T_C$  varies by as much as  $5.7^{\circ}\text{C}$  throughout an orbital period (Figure 17) depending upon the fractional part of the orbital period that the satellite is exposed to the sun.  $T_V$  is known for only one time during an orbital period, at the time the satellite is being interrogated by a Command and Data Acquisition Station, but should be expected to vary as  $T_C$  varies. The variation of  $T_C$  and  $T_V$  during an orbital period is related to the time when the satellite is in the sunlight or the earth's shadow. Figure 17 shows that the maximum  $T_C$  occurs after the satellite enters the earth's shadow and the time of occurrence is a function of the time the satellite is in the sunlight. It also shows that the minimum  $T_C$  occurs after the satellite enters sunlight and the time of occurrence is, likewise, a function of the time the satellite is exposed to the sun during one orbital period.

Figure 16(a) shows the percent of an orbital period that the satellite was in sunlight vs. orbit number for orbits from launch to 1525. Also shown is  $\Delta\phi$ , the difference between the right ascension of the sun and the

orbital ascending node (described in detail in Section 5.1). Figure 18, shows similar information in a different format. This figure gives the fractional part of the 97.4 minute orbital period that the satellite spent in sunlight and the earth's shadow, expressed in minutes after ascending node vs. orbit number. Figure 16(b) shows  $T_V$  and the measured  $T_C$  from launch to orbit 1276, and  $T_V$  and the derived  $T_C$  from orbit 1276 to 1525.

Actually an average  $T_C$  for each orbit is used to reduce all of the data for that orbit on the FMR tape and, thus, as much as a  $\pm 2.85^{\circ}\text{C}$  error in  $T_C$  can be introduced during a portion of the orbit. One can by the use of Figures 17 and 18 establish expressions relating the time of the occurrence of sunlight and shadow and the average  $T_C$ , to give a good approximation of the actual  $T_C$  throughout an orbit. By letting  $T_C$  vary instead of being an average  $T_C$ , a slightly more accurate  $T_{RH}$  or  $\bar{W}$  can be obtained.

### 3.5 Space-Viewed Level

Although there is no specified on-board calibration mechanism on the TIROS VII radiometer, the "space-viewed level" can be considered as a single-point check-of-calibration while in orbit. Any observed shift in the space-viewed level after the original calibration is sufficient but not necessary to indicate a change in the calibration of the instrument (i.e., knowledge of the shift of a given point on a curve is sufficient to indicate a change in position of the curve; whereas, knowledge of the lack of a shift of the point is not sufficient to preclude a rotation of the curve about the point). It is important, therefore, to include a measurement of space-viewed levels in the calibration of the instrument. Within the spectral regions of sensitivity of the emitted thermal radiation channels, radiation from a blackbody target at liquid nitrogen temperatures is practically the equivalent of the radiation levels of outer space. To simulate space radiation for the reflected solar radiation channels, it is necessary only to turn off the lights in the laboratory. The space-viewed levels are calibrated as a function of radiometer housing temperature.

### 3.6 Target Blackbody Temperature, $T_{BB}$ , and Target Effective Radiant Emittance, $\bar{W}$ , versus Digital Number, $D$

The calibration curves and the following discussion are concerned with the original calibration carried out at the Goddard Space Flight Center.

**3.6.1 Emitted Thermal Radiation, Channels 1, 2, and 4.** Two laboratory blackbody targets, placed in a container so that liquid or gaseous nitrogen could flow around them, were used in the calibration procedure. At a certain radiometer housing temperature,  $T_c$ , regulated by the temperature of alcohol flowing through tubes in thermal contact with the radiometer housing in a vacuum chamber, liquid nitrogen, at  $-196^\circ\text{C}$ , was pumped through the tubes in one target while the temperature of the nitrogen flowing through tubes in the other target was varied from  $-196^\circ\text{C}$  to about  $+40^\circ\text{C}$ . This procedure was carried out at seven different radiometer housing temperatures ( $0^\circ$ ,  $7^\circ$ ,  $12^\circ$ ,  $18^\circ$ ,  $25^\circ$ ,  $32^\circ$  or  $35^\circ$ , and  $40^\circ$ ) while viewing the warm target respectively through the wall and floor sides of the radiometer. The temperatures of each target were recorded by means of thermocouples. Using the frequency,  $F_{sc}$ , to digital number,  $D$ , conversion, shown schematically in Figure 10(d), a curve of  $T_{BB}$  vs.  $D$  and  $F_{sc}$  was constructed for each channel on both wall and floor sides for each of the seven values of  $T_c$  (Figures 19-32 and 40-46). If the quantity  $\bar{W}$  is desired, it may be determined from the  $\bar{W}$  vs.  $T_{BB}$  graphs for each channel (Figures 7-9). The complete calibration procedure is shown schematically in Figure 54(a).

**3.6.2 Reflected Solar Radiation Channels 3 and 5.** A tungsten filament lamp calibrated by the National Bureau of Standards was used in the calibration procedure as a standard source. Radiation from the lamp was diffusely reflected from a sheet of white Kodak paper of known spectral reflectivity. The output signal of each channel was read with the illuminated paper normal to rays from the lamp and completely filling one field of view of the radiometer. The other field of view was covered with black tape. In

order to obtain more than one point per calibration, the white paper was placed at different distances from the tungsten lamp. The effective radiant emittance was computed using

$$\bar{W} = \frac{\cos \gamma}{R^2} \int_0^\infty J_\lambda r_\lambda \varnothing_\lambda d\lambda. \quad (5)$$

A curve of  $\bar{W}$  vs.  $V_{R,1D}$  was then constructed, with  $T_c$  being the ambient temperature of the room in which the calibration was made. In order to construct  $\bar{W}$  vs.  $F_{sc}$  curves at various values of  $T_c$ , it was necessary to make additional measurements in vacuum where  $T_c$  could be controlled. Two targets consisting of diffusers illuminated by light bulbs, one target for each of the wall and floor sides, were used for both channels in this calibration. Since the voltages could be regulated, a certain range of voltages was selected and measurements at the various values of  $T_c$  were made of each voltage, recording corresponding radiometer voltage and output frequency at each level. Measurements were made by illuminating alternately both wall and floor sides, keeping the lights off on the side that was to simulate space viewing. In order to correlate the vacuum measurements with the tungsten-filament lamp source measurements, it was necessary to make one set of vacuum measurements at the same  $T_c$  as for the air measurements. By relating bulb voltage levels to  $\bar{W}$  at the air measurements,  $\bar{W}$  vs.  $F_{sc}$  and  $D$  curves were constructed for  $T_c$  of  $0^\circ$ ,  $7^\circ$ ,  $12^\circ$ ,  $18^\circ$ ,  $25^\circ$ ,  $35^\circ$  and  $40^\circ$  (Figures 33-39 and 47-53).

In order to calculate the reflectance (loosely, "albedo") from the incident solar radiation of a spot on earth viewed by the radiometer, one must know the effective solar constant,  $\bar{W}^*$ , the particular value of  $\bar{W}$  which would be measured if the spot viewed were a perfectly diffuse reflector, having unit reflectivity, and illuminated by solar radiation at normal incidence. Using equation (5) for this calculation, and setting  $\gamma = 0^\circ$ ,  $R = 1$  astronomical unit,  $r_\lambda = 1$ , and  $J_\lambda = W_\lambda(T) \times$  (cross-sectional area of sun)/ $\pi$ , we have

$$\bar{W}^* = \frac{\Omega}{\pi} \int_0^\infty W_\lambda(T) \varnothing_\lambda d\lambda. \quad (6)$$

Calculations of  $W^*$  were made taking the sun as a 5800°K blackbody for channel 3 and a 6000°K blackbody for channel 5, yielding values of 484.36 watts/meter<sup>2</sup> and 117.13 watts/meter<sup>2</sup>, respectively. The complete calibration procedure is shown schematically in Figure 54(b).

**3.6.3 History of the Radiometer Subsystem from Initial Calibration Until Launch.** In the original calibration the radiometer was placed in a high vacuum chamber while the electronics canister was placed in a thermally-controlled environmental chamber. Between the original calibration carried out at the Goddard Space Flight Center during the period April 1-27, 1963 and the launch of the satellite on June 19, 1963, several check-of-calibration measurements of all channels were made under varying conditions of pressure (ambient as well as high vacuum) and of housing and infrared target temperatures. These checks indicated that the original calibration of channels 1, 2, 3, and 5 remained essentially unchanged. This behavior contrasted with the behavior of channels 3 and 5 of TIROS IV which showed a marked decrease in response after the original calibration and before launch (see Section 3.6 of *TIROS IV Catalog-Manual*.<sup>1</sup>) The check-of-calibration of channel 4 of TIROS VII, on the other hand, showed a shift to higher frequencies by two and one-half cps. This shift was not due to an increase in the radiometer voltage output, but was due to an increase in the frequency output of the oscillator. Each check-of-calibration was for a relatively short period of time, the longest being about two hours, and it was, therefore, not possible to determine whether the shift was a function of temperature change or a function of the short running time of the radiometer. An in-flight check of the space-viewed level showed that within three days after launch, the frequency had returned to the calibrated space-viewed level. This return was also accompanied by a decrease of  $T_c$  from 20°C to 2°C; however, an increase of  $T_c$  to 27°C on TIROS VII Day 31 was not accompanied by a shift of the frequency and the observed space-viewed

level remained essentially consistent with the calibration through September 30, 1963. The behavior of channel 4 is discussed further in Section VI.

### 3.7 Field of View Measurements

The Barnes Engineering Company made field of view measurements of the various channels of the TIROS VII radiometer. A line source consisting of a filament wire, 0.040 inches in diameter, was used. The line source remained in a plane perpendicular to the geometric axes, about 54 inches from the thermistor bolometers in the wall direction (where 1 inch normal displacement  $\sim 1^\circ$ ). The line source was moved from right to left looking out from the radiometer in the wall direction (horizontal field of view measurements) and from top (up) to bottom (down) in the wall direction (vertical field of view measurements). The line source was kept normal to its direction of motion across the field of view during both horizontal and vertical measurements. These measurements are shown in Figures 55-59. Laboratory measurements for the floor side are not available.

Alignment measurements were made by RCA after the radiometer was mounted on the base plate of the satellite. A line source was moved from top to bottom to determine the vertical field of view from the wall side. These measurements and resulting computations to determine the optical angle with respect to the base plate and the error angle from the design-value of  $45^\circ$  to the spin axis are given in Table XIII. These measurements show that the optical axes for channels 1, 3, and 5 are very nearly coincident with the  $45^\circ$  line, whereas, for channels 2 and 4 the optical axes are misaligned by approximately  $13\frac{1}{4}^\circ$  and  $11\frac{1}{4}^\circ$ , respectively; and are misaligned relative to each other by  $3^\circ$ .

### 3.8 Summary of the Calibration

When a certain value of effective radiant emittance  $\bar{W}$  or equivalent blackbody temperature  $T_{bb}$  is viewed by the radiometer through a given side with a given radiometer housing temperature an output signal  $F_{sc}$

results. If  $T_E$  and  $T_C$  are within  $\pm 7^\circ\text{C}$  of the relationship,

$$T_E = T_C + 10^\circ\text{C}$$

and if the  $T_C$ 's, deduced from the component temperature,  $T_v$ , are correct, only a negligible error in  $T_{RH}$  or  $\bar{W}$  is introduced. From  $F_{sc}$  and  $T_C$ , which are measured independently, the measured value of  $T_{RH}$  or  $\bar{W}$  can be determined from the calibration curves.

The calibration for each side of each channel is carried out for seven parametric values of  $T_r$ ; hence, it is necessary to interpolate between two transfer functions bracketing an actual value of  $T_r$  to arrive at the calibration for a given orbital period.

## IV. RADIATION DATA PROCESSING

### 4.1 *Information Flow in the Satellite*<sup>6,45</sup>

The radiation experiment instrumentation is independent of the television camera system except for power, command, certain timing signals, and antennas (Figure 60). The output of the five medium resolution radiometer channels is fed into five subcarrier oscillators. These voltage controlled oscillators are of the phase shift type with symmetric amplifiers in the feedback loops, the gains of which are controlled by the balanced input signal. A sixth channel is provided for telemetry of the University of Wisconsin's heat balance data; data from an electron temperature measuring probe; the environmental temperatures; and the instrumentation canister pressure. In channel 6, a mechanical commutator switches resistive sensors in one branch of a phase shift oscillator. These sensors stopped switching after orbit 1276 in TIROS VII and remained set on the electron temperature probe sensor. Thereafter, the radiometer housing temperature (one of the environmental temperatures) was derived from the TV clock No. 2 temperature of the satellite, available upon interrogation. The seventh channel, a tuning fork oscillator, serves as a reference frequency and timing signal. The outputs from each of the seven channels are summed

and the resultant composite signal equalized in a record amplifier which drives the head of a miniature tape recorder. An oscillator provides an alternating current bias to the record head and the signal required for the erase head. For convenience, erase of the magnetic tape occurs immediately before recording. The record spectrum extends from 100 cps to 550 cps. The tape recorder is an endless-loop, two speed design running at 0.4 ips record and 12 ips playback speed. The endless loop records continuously, day and night, except during a playback sequence. A hysteresis synchronous motor generates torque in the record mode through a mylar belt speed reduction. The fourth subharmonic of the tuning fork oscillator, generated by flip flops, drives a cam shaft which activates a bank of microswitches connected to the five commutated subchannels of the time-sharing sixth channel. Each is sampled for six seconds and the fifth includes a group of seven to be subcommutated.

Playback is initiated upon command by applying power to a direct current motor. A magnetized flywheel generates a frequency proportional to the motor speed. A frequency discriminator feeds the error signal to the stabilized power supply of the motor and closes the servo loop. Playback speed is essentially constant from  $0^\circ$  to  $50^\circ\text{C}$ . A low flutter and wow of 2.5% peak-to-peak, measured without frequency limitations, is achieved by using precision bearings and ground-in-place shafts having tolerances of better than 50 parts per million. A command pulse activates the playback motor, the playback amplifier, and the 238 mc FM telemetry transmitter feeding the duplexer and antenna.

The playback time, approximately 200 seconds, is controlled by a switch which operates only during the playback mode. This switch rotates one revolution in 200 seconds, activating a microswitch which returns the system to the record mode and, thus, terminates the playback mode with one complete revolution of the magnetic tape. However, the playback mode experienced a malfunction at low temperatures in TIROS



VII from Orbit 573. Due to an apparent frictional drag on the shaft by the clutch in the mechanical linkage from the record motor to the reduction gears, the switch was rotated during the record mode. Consequently, at the start of the playback mode, the switch was in such a position that less than one complete revolution of the tape was required before the switch activated the return to record mode. This necessitated another command signal to be sent to initiate a second and complete playback of the tape. Some data were lost, since at the termination of the first playback, the record mode erased the data on the tape; thus, only data from the end-of-tape to the beginning of the second playback were recovered. Fortunately, the first playback, although variable in length, was short, resulting in the loss of only a small amount of data from each orbit.

In order to permit comparison of the radiation data with TV pictures, each TV shutter action generates a 1.5 second pulse which is recorded as an amplitude modulation of the channel 7 timing signal.

There are nine solar cells mounted behind narrow slits for north angle determination. These slits have an opening angle of close to  $180^\circ$  in planes through the spin axis. The sun illumination generates pulses as long as illumination parallel to the spin axis is avoided. One of these sensors generates a 0.5 second pulse in addition to the north indicator code so that spin rate information and a measurement of relative sun position is available. Again, this pulse is recorded as an amplitude modulation of channel 7.

Reconstruction of the radiation information vitally depends on its correlation with absolute time. An accurate, but relative, timing signal is provided for by the tuning fork oscillator and a crude one by the sun pulses, except when the satellite is in the earth's umbra. Absolute time is transmitted to the satellite and recorded on the tape as a one-second dropout of channel 7. This pulse is designated as the End-of-Tape (E.O.T.), and its occurrence is known within milliseconds of absolute time.

#### 4.2 *Information Flow at the Command and Data Acquisition Station*<sup>6,45</sup>

Upon interrogation, the 238 mc carrier is received by an antenna; the composite signal is recorded on magnetic tape and simultaneously fed to a "Quick Look" demodulator (Figure 61a). At the same time, the envelope of channel 7 and the clipped signal of channel 2 are graphically recorded. The 8-12 $\mu$  "events" on the graphic record show alternately the earth and sky scan intervals as the satellite spins and progresses along the orbit. The channel 7 envelope shows the three distinctive types of AM pulses impressed on the clock frequency during recording; namely, the sun sensor pulses, the TV camera pulses, and the "end-of-tape" pulse. Auxiliary uses of the radiation data (Figures 61b and 61c) include determination of the spin axis attitude in space and the times when the TV pictures were taken and recorded in the satellite to be read out later over a ground station.

The magnetic tapes are, then, routinely mailed every day to the Aeronomy and Meteorology Division, GSFC, Greenbelt, Maryland.

#### 4.3 *Information Flow at the Data Processing Center*<sup>6,45</sup>

At the Data Processing Center of the Aeronomy and Meteorology Division, the master tapes containing the composite radiation signal are demultiplexed, demodulated, and fed into an analog-to-digital converter (Figure 62). The pressure is read separately. The analog-to-digital converter produces a magnetic "Radiation Data Tape" made up of 36 bit words suitable for an IBM 7094 computer. The sampling rate for data acquired between launch and orbit 1072 was the same as it had been on all previous TIROS five-channel radiometer experiments, i.e., one data sample for every 72nd cycle of the 550 c.p.s. channel 7 clock (or one sample every 0.1309 seconds). *To increase the resolution of the reduced data, the sampling rate was increased by a factor of two beginning with orbit 1080.* For orbit 1080 and all later orbits, therefore, a data sample was digitized

for every 36th clock cycle (or one sample every 0.06545 seconds). The result of this action was merely to double the number of data samples on the FMR tape. An auxiliary form for the repository of the radiation data is the oscillogram, or analog record, produced at this stage of the information flow. The analog record can be used for special "hand" analyses of the data.

#### 4.4 *Information Flow at the Data Reduction Center*

The IBM 7094 computer program requires input from three sources to produce, in binary form, the "Final Meteorological Radiation (FMR) Tapes". One source is the "Radiation Data Tape" containing radiation data and satellite environmental parameters in digital form. Another source is the calibration data for converting digital information to meaningful physical units. The third source is the "Orbital Tape" from the NASA Space Computing Center containing satellite position and attitude data as a function of time. The FMR tape then is the basic repository of data from the medium resolution scanning radiometer. In order to study and utilize the scanning radiometer data, appropriate computer programs must be written to read the FMR tape and provide for printing out data, punching cards, or producing maps. The format of the FMR tape and the make-up of the IBM 7094 computer program which produces it are discussed in detail in sections 4.5 and 4.6.

#### 4.5 *Format of the "Final Meteorological Radiation Tape"*

TIROS VII radiation data are available on high density, binary tapes prepared on an IBM 7094 computer. The FMR tape is the product of a computer program whose input is the orbital data, digitized radiation data, and TIROS VII radiometer calibration data. The make-up of this program is discussed in section 4.6. The FMR tape contains calibrated radiation measurements, geographical locations associated with the radiation measurements, orbital data, solar ephemeris, and satellite environmental temperatures. The exact format of these data is described

below. The purpose of this section is to emphasize certain features that will aid programmers in utilizing these data.

Each orbit of radiation data is treated as a file which contains a documentation record plus data records that represent approximately one minute intervals of time. The documentation record is the first record of each file and contains 14 data words whose format is described below. Dref is defined as the number of days between zero hour of September 1, 1957, and zero hour of launch date. TIROS VII time counts zero time as zero hour at Greenwich on the day of launch, thus launch time is given in GMT and launch day is zero day, with succeeding days numbered sequentially. However, the satellite life extends beyond 100 days, and for each succeeding period of approximately 100 days the value of dref is redefined by adding approximately 100, while the TIROS VII day is decreased by the same amount.

Each record of data covers approximately one minute of time, and the data are found in the decrement (D) and address (A) of each data word. The record terminates with the end of swath in progress at 60.0 seconds past the minute specified in words 1D, 1A, and 2D. In the case of satellite-earth orientation such that the radiometer continuously scans the earth for more than one rotation of the satellite, the record will terminate with the end of the revolution in progress at 60.0 seconds past the minute specified in words 1D, 1A, and 2D. The End of File gap will be duplicated at the end of the last file on each FMR tape.

For each earth-viewing swath, the radiation measured from channel 1 ( $14.8\text{--}15.5\mu$ ), channel 2 ( $8.0\text{--}12.0\mu$ ), and channel 4 ( $8.0\text{--}30.0\mu$ ) is reported as an equivalent black-body temperature in  $^{\circ}\text{K}$ , while the radiation measured from channel 3 ( $0.2\text{--}6.0\mu$ ) and channel 5 ( $0.55\text{--}0.75\mu$ ) is reported as an effective radiant emittance in  $\text{watts/meter}^2$ . For each fifth measurement in a swath, the point on earth being "viewed" by the radiometer is defined in terms of latitude and longitude. These computations are based on

the best available estimate of satellite attitude.

In order that the user may distinguish between data from the wall and floor sides of the satellite, the data words containing the measured energy are labeled with a 1 in position 19 when the wall side of the satellite is viewing the earth. The user should realize that if the signal from the satellite becomes noisy, swath sizes, as interpreted by the computer, may become abnormal and the data can be labeled and located incorrectly. In order to flag abnormal data, minus signs are inserted for the following three reasons:

1. A measurement within a swath whose digital response falls below the arbitrarily defined threshold between earth and space. (The end of a swath is arbitrarily defined by three consecutive measurements falling below the threshold.)

2. An entire swath is labeled with minus signs when the observed swath size falls outside of the theoretical swath size  $\pm 25\%$ . The theoretically computed swath size is based on the best available estimate of satellite attitude, height, and spin rate.

3. The entire swath is labeled with minus signs when it is either the first or last swath

in the closed mode. (In the closed scanning mode the radiometer continuously scans over the earth for more than one spin revolution without viewing the horizon or space.)

Channel 3 and channel 5 on TIROS VII can reach a saturation limit at lower radiation intensities than has been the case with any previous satellite. In order to detect this condition, the data word containing energy measured by channel 3 and channel 5 is labeled with a "one" in position 18 whenever the observed energy intensity exceeds the saturation limit. Saturation limits for the wall and floor sides separately are indicated at the upper right-hand extremities of the calibration curves for channel 3 (Figures 33-39) and channel 5 (Figures 47-53). For example in Figure 33 the effective radiant emittance "saturates" at 344.0 watts/meter<sup>2</sup> for the floor side and 333.0 watts/meter<sup>2</sup> for the wall side. *If any higher values of radiant emittance should actually be viewed by the radiometer, they would still be reported as the "saturation values" on the FMR tape.* However, in practice measurements exceeding the "saturation limits" have only rarely been observed in TIROS VII (except in periods when direct solar interference occurs; see Section VI below).

## FORMAT OF FINAL METEOROLOGICAL RADIATION TAPE

### Documentation Record

Word No.	Quantity	Units	Scaling	Remarks
1 -----	Dref -----	-----	$B = 35$	Number of days between zero hour of Sept. 1, 1957, and zero hour of launch day.
2 -----	Date -----	-----	-----	Date of Interrogation expressed as a packed word, i.e., February 8, 1964 would be (020864) <sub>10</sub> or (021004) <sub>10</sub> . These numbers are shifted to the extreme right side of the data word. Only the last digit of the year is retained for 1964.
3 -----	Day -----	TIROS VII Day ---	$B = 35$	Start time of this file of radiation data.
4 -----	Hour -----	Z Hour -----	$B = 35$	
5 -----	Minute -----	Z Minute -----	$B = 35$	
6 -----	Seconds -----	Z Seconds -----	$B = 26$	
7 -----	Day -----	TIROS VII Day ---	$B = 35$	Time of Interrogation, i.e., end time of this file of radiation data.
8 -----	Hour -----	Z Hour -----	$B = 35$	
9 -----	Minute -----	Z Minute -----	$B = 35$	
10 -----	Seconds -----	Z Seconds -----	$B = 26$	

Word No.	Quantity	Units	Scaling	Remarks
11 -----	Satellite Spin Rate -----	Deg/Sec -----	$B = 26$	Satellite spin rate.
12 -----	Frequency -----	36,72,144 -----	$B = 35$	Data sampling frequency (cycles of a 550 cps tuning fork).
13 -----	Orbit No. -----	-----	$B = 35$	Orbit No. at time of Interrogation.
14 -----	Station Code -----	-----	$B = 35$	Code defining ground station ("1" for Wallops Is., Va., "2" for San Nicolas Is., Calif., "3" for Fairbanks, Alaska).

*Format of FMR Tape—Nth Record*

1D -----	Day -----	-----	$B = 17$	TIROS VII Day
1A -----	Hour -----	-----	$B = 35$	Z time in day specified in word 1D
2D -----	Minute -----	-----	$B = 17$	Greenwich hour angle and declination of sun at time specified in words 1D, 1A, and 2D. 90° are added to declination to yield positive numbers.
2A -----	GHA -----	Degrees -----	$B = 29$	
3D -----	Decl. -----	Degrees -----	$B = 11$	
3A -----	$T_c$ -----	Degrees K -----	$B = 35$	Reference temperature of the medium resolution radiometer.
4D -----	$T_E$ -----	Degrees K -----	$B = 17$	Reference temperature of main deck electronics.
4A -----	Height -----	Kilometers -----	$B = 35$	Height of satellite at time specified in words 1D, 1A, and 2D.
5D -----	Latitude -----	Degrees -----	$B = 11$	Latitude of subsatellite point at time specified in words 1D, 1A, 2D. 90° are added to all latitudes to yield positive numbers.
5A -----	Longitude -----	Degrees -----	$B = 29$	Longitude of subsatellite point at time specified in words 1D, 1A, 2D. Longitudes are reported as 0 to 360°, with west being positive.
6D -----	Seconds -----	-----	$B = 8$	Seconds past time specified in words 1D, 1A, 2D when first earth-viewing response is detected, and every fifth response thereafter.
6A -----	Latitude -----	Degrees -----	$B = 29$	Latitude of subsatellite point at time specified in words 1D, 1A, 2D, 6D. 90° are added to all latitudes to yield positive numbers.
7D -----	Longitude -----	Degrees -----	$B = 11$	Longitude of subsatellite point at time specified in words 1D, 1A, 2D, 6D. Longitudes are reported as 0 to 360°, with west being positive.
7A -----	Latitude -----	Degrees -----	$B = 29$	Latitude of point on earth being "viewed" by radiometer at time specified in words 1D, 1A, 2D, 6D. 90° are added to all latitudes to yield positive numbers.

Word No.	Quantity	Units	Scaling	Remarks
8D -----	Longitude -----	Degrees -----	$B = 11$	Longitude of point on earth being "viewed" by radiometer at time specified in words 1D, 1A, 2D, 6D. Longitudes are reported as 0 to 360°, with west being positive.
8A -----	Nadir Angle -----	Degrees -----	$B = 29$	Nadir angle of optic axis from radiometer to point specified in words 7A, 8D.
9D -----	Azimuth Angle -----	Degrees -----	$B = 11$	Azimuth angle of optic axis from radiometer to point specified in word 7A, 8D. This angle is measured clockwise from north and expressed as a positive number.
9A -----	Zero -----	-----	-----	-----
10D -----	$T_{RR}$ (ch. 1) -----	Degrees K -----	$B = 14$	Measurement by each of the five medium resolution channels at time specified in 1D, 1A, 2D, 6D when radiometer is "viewing" point on earth specified in words 7A, 8D.
10A -----	$T_{RR}$ (ch. 2) -----	Degrees K -----	$B = 32$	
11D -----	$\bar{W}$ (ch. 3) -----	Watts/m <sup>2</sup> -----	$B = 14$	
11A -----	$T_{RR}$ (ch. 4) -----	Degrees K -----	$B = 32$	
12D -----	$\bar{W}$ (ch. 5) -----	Watts/m <sup>2</sup> -----	$B = 14$	
12A -----	Zero -----	-----	-----	-----
13D -----	$T_{RR}$ (ch. 1) -----	Degrees K -----	$B = 14$	The data sample immediately following the measurement recorded in words 10D-12A.
13A -----	$T_{RR}$ (ch. 2) -----	Degrees K -----	$B = 32$	
14D -----	$\bar{W}$ (ch. 3) -----	Watts/m <sup>2</sup> -----	$B = 14$	
14A -----	$T_{RR}$ (ch. 4) -----	Degrees K -----	$B = 32$	
15D -----	$\bar{W}$ (ch. 5) -----	Watts/m <sup>2</sup> -----	$B = 14$	
15A -----	Zero -----	-----	-----	-----
16D -----	$T_{RR}$ (ch. 1) -----	Degrees K -----	$B = 14$	The data sample immediately following the measurement recorded in words 13D-15A.
16A -----	$T_{RR}$ (ch. 2) -----	Degrees K -----	$B = 32$	
17D -----	$\bar{W}$ (ch. 3) -----	Watts/m <sup>2</sup> -----	$B = 14$	
17A -----	$T_{RR}$ (ch. 4) -----	Degrees K -----	$B = 32$	
18D -----	$\bar{W}$ (ch. 5) -----	Watts/m <sup>2</sup> -----	$B = 14$	
18A -----	Zero -----	-----	-----	-----
19D -----	$T_{RR}$ (ch. 1) -----	Degrees K -----	$B = 14$	The data sample immediately following the measurement recorded in words 16D-18A.
19A -----	$T_{RR}$ (ch. 2) -----	Degrees K -----	$B = 32$	
20D -----	$\bar{W}$ (ch. 3) -----	Watts/m <sup>2</sup> -----	$B = 14$	
20A -----	$T_{RR}$ (ch. 4) -----	Degrees K -----	$B = 32$	
21D -----	$\bar{W}$ (ch. 5) -----	Watts/m <sup>2</sup> -----	$B = 14$	
21A -----	Zero -----	-----	-----	-----
22D -----	$T_{RR}$ (ch. 1) -----	Degrees K -----	$B = 14$	The data sample immediately following the measurement recorded in words 19D-21A.
22A -----	$T_{RR}$ (ch. 2) -----	Degrees K -----	$B = 32$	
23D -----	$\bar{W}$ (ch. 3) -----	Watts/m <sup>2</sup> -----	$B = 14$	
23A -----	$T_{RR}$ (ch. 4) -----	Degrees K -----	$B = 32$	
24D -----	$\bar{W}$ (ch. 5) -----	Watts/m <sup>2</sup> -----	$B = 14$	
24A -----	Zero -----	-----	-----	-----

The block of data from words 6D to 24A will be repeated, thus defining every fifth measurement in a swath. The address of the third word in the last response of a swath will contain 0101010101010 to signal end of record. A "look ahead" feature is incorporated into TIROS VII data reduc-

tion; if the End of Tape signal occurs within an earth-viewing swath, that entire swath is discarded. Each time the swath terminates, two words (N and N+1) will follow the last "earth-viewing" response with the following format:

Word No.	Quantity	Units	Scaling	Remarks
ND -----	Code -----	1111111111111111	-----	Code indicating end of swath
NA -----	Nadir Angle -----	Degrees -----	$B = 29$	The minimum nadir angle that occurred in the previously defined swath
(N+1)D -	Latitude -----	Degrees -----	$B = 11$	Latitude of point on earth being "viewed" by radiometer when the minimum nadir angle occurred. 90° are added to all latitudes to yield positive numbers
(N+1)A -	Longitude -----	Degrees -----	$B = 29$	Longitude of point on earth being "viewed" by radiometer when minimum nadir angle occurred. Longitudes are reported as 0 to 360°, with west being positive.

Occasionally dropouts are encountered and the corresponding data records contain no radiation data. This event is relatively rare in TIROS VII data, but in such cases the radiation data record contains only five words (1D to 5A) which document the record with respect to time. In such records, the datum in the address of the third word ( $T_c$ ) is destroyed by the End of Record code.

A flow diagram to aid in interpreting this format is shown in Figure 63. It is seen that the format is analogous to four "nested loops" (in programming language), i.e., groups of five responses, entire swaths, one-minute records, and files. It is pointed out that a particular swath (and, hence, a particular record and a particular file) can end either on the "anchor data response" or on any of the four following non-geographically located data responses and that Figure 63 merely illustrates one possible combination of ending responses.

#### 4.6 IBM 7094 Computer Flow Diagram

The FMR tape as described in the previous section is prepared with an IBM 7094 computer program whose input consists of orbital data, digital radiation data, and TIROS VII radiometer calibration data. The flow chart shown in Figure 64 outlines the logical steps in this program and thus gives some insight into the mechanics of preparing these tapes. The flow chart has been greatly

condensed since it is impossible to present a detailed flow chart within the space limitations of this publication.

The first phase of this program sets up the documentation data and then reads the entire file of radiation data to compute the start time from the end-of-tape time and the data sampling frequency. Given the starting and ending times, the program then searches the orbital tape to find orbital data (subsattellite point, height, nadir angle, right ascension, and declination) covering the same time interval. These data are then arranged in tables as a function of time so that interpolation subroutines can be used in the second phase to obtain values of the orbital characteristics for any specified time.

At this point, an optional feature allows the program to accept the attitude data from the orbital tape, or an alternate estimate of the attitude from a second documentation card. If the alternate attitude is accepted, the nadir angles are recomputed.

The second phase of the program reduces the digitized radiation data into useful meteorological data. This begins with a detailed examination of the radiation data to distinguish between earth and space-viewed data. This distinction is based on an arbitrarily defined threshold value applied to channel 2. Both sides are assumed to be viewing space when the measured radiation falls below the

threshold value, and one side is viewing the earth when the measured radiation exceeds the threshold value. The end of swath is arbitrarily defined as three consecutive space-viewed measurements.

For each earth-viewing swath, the program proceeds to determine which side is viewing the earth, computes the latitude and longitude of the point on earth being "viewed" by the radiometer for each fifth measurement in the swath, and converts the digitized data into radiation units for each measurement in the swath. The data words containing radiation measurements contain a "1" in position 19 when the wall side is viewing the earth, and a "1" in position 18 when the response from channel 3 or channel 5 exceeds saturation.

Each record on the FMR tape covers approximately one minute of time and terminates with the end of swath in progress at 60.0 seconds past the minute. When the end of tape is encountered, the program writes the last data record and reinitializes in preparation for the next orbit of radiation data.

## V. RADIATION DATA COVERAGE AND DOCUMENTATION

### 5.1 Radiation Data Coverage

The discussion in this section concerning the radiation data coverage parallels the discussion by Widger and Wood<sup>46</sup> on the photographic coverage by the TIROS satellite.

The geographical area from which significant meteorological radiation data are obtained by TIROS VII is limited mainly to the area between 58.2°N and 58.2°S. The latitudinal limitation is due to the 58.2° inclination of the orbital plane to the equatorial plane.

The longitudinal limitation is imposed on obtaining radiation data due to the location of the Command and Data Acquisition stations since the range at which each station can contact the satellite and acquire data is limited to the line of sight from the ground to the satellite. To obtain as noise-free data as possible the antenna elevation angles are

generally limited to a minimum of 10° above the horizon. Figure 65 shows the data acquisition circles for a 10° antenna elevation angle at Wallops Island, Virginia; San Nicolas Island, California; and Fairbanks, Alaska. Mountain ranges south of the Fairbanks station prevent the acquisition of data for elevation angles less than 17.8° which causes a perturbation of the 10° elevation circle between azimuth angles of 158° and 202° (measured clockwise from true north).

Figure 65 also shows the trace of the subpoint tracks for 10 successive orbits. This series of tracks shows that only a maximum of 9 orbits can be interrogated in one interrogation day. If orbit N can just be acquired by the Wallops Island station, then orbit N+9 is the first orbit which cannot be acquired by the Fairbanks station. The dashed line shows the last orbit which may be acquired by Fairbanks. Orbits with ascending nodes from longitude 70°E westward to longitude 75°W cannot be acquired by any of the stations. Also orbit N+4 is only rarely acquired since either its subpoint track falls between the San Nicolas and Fairbanks acquisition circles or if the track does cross the Fairbanks circle, there is insufficient time to playback the data.

The interrogation day includes all orbits interrogated in the series of 9 consecutive orbits which come within range of the acquisition stations during each 24-hour period as shown in Figure 65. The interrogation day can and often does occur on two separate calendar days. The shaded area of Figure 65 shows the geographical area where nearly all radiation data are acquired. The unshaded areas between 58.2°N and 58.2°S latitude show the longitudinal limitation on the acquisition of data due to the location of the acquisition stations. Because of the inclination of the sensors to the spin vector and/or the precession of the spin vector, some data are acquired to about 69°N and 69°S latitude. However, the number of data samples acquired in this area is small compared to the number in the shaded area of Figure 65.

Further latitudinal limitations are imposed on obtaining reflected solar radiation meas-

urements because of the need for solar illumination. Because of the slight bulge of the earth at the equator, the satellite orbital plane precesses in right ascension at the rate of  $-3.76$  deg/day. This is illustrated in Figure 66, where the spin vector and orbital plane orientation for selected orbits of TIROS VII, as viewed from the sun, are shown. The quantity  $\Delta\varnothing$  is defined as the right ascension of the sun minus the right ascension of the orbital ascending node. Due to the precession of the orbital plane and the movement of the earth in its orbit, a complete cycle of the precession of the plane of the satellite's orbit relative to the sun (synodic period) is completed in about 75.9 days.

For any single day the plane of the satellite orbit remains nearly fixed in absolute space while the earth rotates within the orbit. Thus, at a given latitude and considering only solar illumination, reflected solar radiation could be obtained for all longitudes during any single day. The precession of the orbital plane causes the illuminated latitudes, as seen by the satellite, to change during one synodic period as described below. In the following discussion, the solar illuminated area (where solar radiation data are available) is defined by requiring the solar zenith angle to be less than  $70^\circ$  and the "scan nadir angle" (i.e., the nadir angle of the radiometer optical axis) to be less than  $58^\circ$ . The following discussion is concerned only with the availability of reflected solar radiation measurements.

The time of the TIROS VII launch was chosen so that the heliocentric orbital geometry shown in Figure 66a resulted, and reflected solar radiation data were obtained from about  $26^\circ\text{S}$  to  $69^\circ\text{N}$  latitude. After about 10 days, the orbital plane and the sun have moved to a  $\Delta\varnothing$  of  $180^\circ$  (Figure 66b) which means that the descending node occurs on the meridian of the subsolar point. At this time, reflected solar radiation data can be obtained from about  $46^\circ\text{S}$  to  $69^\circ\text{N}$  latitude. By TIROS VII Day 29, or 29 sequential days after launch day,  $\Delta\varnothing$  is  $270^\circ$  (Figure 66c)

and the southern part of the orbit is over the sunlit side of the earth, while the northern portion of the orbit is on the dark side. However, since the subsolar point is in the Northern Hemisphere at a declination of  $21.1^\circ$ , and since useful solar radiation data are defined for a solar zenith angle of less than  $70^\circ$ , only latitudes north of about  $49^\circ\text{S}$  are thus illuminated. Therefore, solar radiation data are not available because the data are obtained south of  $49^\circ\text{S}$  on the sunlit side of the earth, while the satellite is in the Northern Hemisphere only at night. On TIROS VII Day 48,  $\Delta\varnothing$  is  $0^\circ$  and the ascending node of the orbit is on the sunlit side of the earth (Figure 66d). Reflected solar radiation data are available from  $53^\circ\text{S}$  to  $69^\circ\text{N}$  latitude. Continued precession until TIROS VII Day 67 moves the orbit to a  $\Delta\varnothing$  of  $90^\circ$  (Figure 66e) where the solar data coverage is from  $8^\circ\text{N}$  to  $69^\circ\text{N}$  latitude. At this time the satellite is in the Southern Hemisphere only at night. On approximately TIROS VII Day 75.9, the orbital plane has the same orientation with respect to the sun as at launch. The whole precession cycle then repeats with a synodic period of about 75.9 days throughout the satellite's lifetime. The northern and southern latitudinal limits of reflected solar radiation coverage vary from one synodic period to the next due to the changing subsolar latitude.

The reflected solar radiation coverage for TIROS VII from June 19, 1963 to September 30, 1963 is summarized in Figure 67. The shaded area indicates the illuminated latitudes for each TIROS VII Day. Disregarding the solar illumination requirement, the medium resolution radiometer latitude coverage extends from  $69^\circ\text{N}$  to  $69^\circ\text{S}$ . However, reflected solar data could not be acquired for all latitudes between  $69^\circ\text{S}$  and  $69^\circ\text{N}$  due to inadequate illumination and the position of the orbital plane in relation to the sun. Reflected solar data for one period (centered at TIROS VII DAY 29) were essentially nonexistent since the satellite was in the northern hemisphere at night and crossed the high poorly-illuminated latitudes in the sunlit southern hemisphere in the daytime.



## 5.2 Documentation of Radiation Data

The radiation data available on the FMR tapes have been documented in an Index of Final Meteorological Tapes. This Index, which is found in Appendix A, lists information for the orbital ascending node, the spin vector attitude, and the spin rate for every TIROS VII orbit for which radiation data are available. The time interval for which radiation data are available in each processed orbit is also listed in Appendix A.

For each interrogation day, the time interval for the radiation data on the FMR tapes is summarized diagrammatically on the subpoint tracks for that day. Information concerning the minimum nadir angle is also included. The presentations are located in Appendix B and are identified by calendar date. This presentation allows the user to find applicable orbits quickly and approximate the geographical area of radiation data coverage. The user of reflected solar radiation data should also refer to Figure 67 to determine the latitudinal extent of the reflected solar radiation data coverage.

# VI. PRE-LAUNCH AND POST-LAUNCH PERFORMANCE OF THE RADIATION EXPERIMENT

## 6.1 Pre-Launch Behavior of the Experiment

As indicated in Section 3.6 pre-launch checks of calibration made between 27 April and 19 June 1963 did not indicate any change in the response of channels 1, 2, 3, and 5. But due to an apparently unstable transistor, the channel 4 oscillator frequency-vs.-voltage curve was observed to have shifted upward about  $2\frac{1}{2}$  c.p.s. several days before shipment of the radiometer from the RCA factory to Cape Kennedy. This effect persisted for a few days after launch, after which it was observed to diminish (cf. Figure 68a).

Although pre-launch calibration tests did not show any degradation for channels 3 and 5, their initial "quasi-global" albedos are considerably lower than expected and required for internal consistency with meas-

urements from the long-wave channels. Therefore, the possibility of a degradation of channels 3 and 5 occurring sometime before acquiring data from the first orbit can not be discounted; on the other hand, the explanation may lie in other areas, as yet undetermined.

## 6.2 Post-Launch Behavior of the Experiment

There is strong evidence that all channels of the TIROS VII medium resolution radiometer changed in response after going into orbit, as did all channels of previous instruments flown on TIROS II, III, and IV.<sup>47,1</sup> The post-launch degradation has been observed in two ways. First, as pointed out in Section 3.5 the space-viewed level can be considered to be a single-point check of calibration, and any shift observed in this level after the original calibration indicates that a change has occurred in the system. A shift could be caused by an imbalance which develops between the floor and wall optical paths in one of the emitted thermal radiation channels, or by a drift of the transfer functions of the satellite-borne electronics associated with either the reflected solar or thermal radiation channels (a detailed discussion of possible mechanism's for explaining instrumental degradation is found in the "TIROS III Radiation Data Users' Manual Supplement"<sup>47</sup> and will not be repeated here). Because the ground demodulation equipment is readily accessible and constantly checked and aligned, the possibility of its contributing to a persistent shift in the space-viewed level can be discounted.

The weight of evidence to date indicates that the primary cause of shifts of the space-viewed levels of the thermal radiation channels of previous TIROS radiometers has been an imbalance which developed between the floor and wall paths of the optics. This type of degradation is accompanied by characteristic "negative-going pulses" and is called "asymmetrical optical degradation."<sup>47</sup> Because a shift in the space-viewed level due to asymmetrical optical degradation results from chopped thermal radiation emitted

from components of the radiometer within the passband of the filter, it follows that this type of degradation cannot be a cause of a shift in the space-viewed levels of the reflected solar radiation channels which are not sensitive in the infrared. In the period between launch and 30 September 1963 no appreciable asymmetrical optical degradation was detected in any of the channels of the TIROS VII radiometer.

However, for the first time, strong evidence exists that "electronic degradation" occurred in TIROS VII. Electronic degradation is uniquely characterized by a shift in the space-viewed level (without accompanying negative-going pulses in the case of a thermal radiation channel).<sup>47</sup> As previously indicated, this type of degradation was observed before and immediately after launch in channel 4. The shifts of the space-viewed levels,  $\Delta F$ , of all channels of TIROS VII are shown in Figures 68a and 68b. Evidence of electronic degradation occurring in the channel 4 oscillator is seen in the initial  $\Delta F$  value of 2.5 c.p.s. This value decreases rapidly within the first several days and remains at a value of about -0.75 c.p.s. for the remainder of the first 1525 orbits. Because of certain inaccuracies in determining the space-viewed levels, values of  $\Delta F$  whose absolute magnitudes are less than 1 are not considered to be significant. Using this criterion there is evidence of some electronic degradation in channel 3 after orbit 500 when its  $\Delta F$  dips slightly below -1.0 and stays there for the remainder of the first 1525 orbits. The  $\Delta F$  values of all other channels generally stay within  $\pm 1$  c.p.s. throughout the first 1525 orbits.

As pointed out in the "TIROS III Supplement,"<sup>47</sup> it is very difficult to distinguish between the effects of a rotation in the oscillator transfer function and symmetrical optical degradation; hence, we shall adopt a "compound degradation model" which considers electronic degradation and which may or may not include symmetrical optical degradation. A schematic representation of this model is shown in Figure 69. The single transfer function shown applies to the combination of a voltage controlled oscillator

and its associated radiometer channel (cf. Figure 10). From Figures 33-39 and 47-53 it is seen that the idealized linear transfer function of Figure 69 is a fairly good approximation. From Figure 69 it follows that the correction for a degraded measurement,  $\overline{W}$ , is given by

$$\overline{W} = \kappa^i [\overline{W}' + \rho^i] \quad (7)$$

where  $\kappa^i$  and  $\rho^i$  are parameters which are a function of the orbit number,  $i$ . When there is no shift in the space-viewed level (i.e., when  $\Delta F = 0$  and, therefore,  $\rho^i = 0$ ), Equation (7) reduces to the form

$$\overline{W} = \kappa^i \overline{W}' \quad (8)$$

which is equivalent to that employed in the symmetrical optical degradation model.<sup>47</sup>

Symmetrical optical degradation may exist for all channels without any shift occurring in the space-viewed levels. In the absence of an adequate on-board calibration, this type of degradation has been indicated by the behavior of large quantities of data analyzed statistically by a computer program originally designed to study the "quasi-global" heat balance. This program (designed for the earlier TIROS experiments where the orbital inclinations were 48°) analyzes data acquired within the broad zone between 55°N latitude and 55°S latitude. In applying this program to TIROS VII, some high-latitude data are rejected because, with a 10°-larger orbital inclination, additional radiation measurements were made poleward of the 55° latitudes. Also (as in the previous TIROS experiments) there are areas equatorward of the 55° latitudes where data cannot be acquired due to the locations of the Command and Data acquisition stations. Nevertheless it was felt justified to use the existing computer program, with some modifications, to investigate possible degradation of the TIROS VII radiometer sensors. Throughout this volume, then, the term "quasi-globe" shall refer to that portion of the broad zone between 55°N latitude and 55°S latitude where data were acquired by the TIROS VII radiometer.

The "heat balance" program was designed to convert individual measurements from

channels 2 and 4 to total outgoing long-wave flux,  $W$ , by the methods given by Wark, Yamamoto, and Lienesch<sup>33</sup> and to average the calculations accumulated throughout a sustained period over time and area to yield the "cumulative quasi-global emitted radiant power." The program was also designed to calculate reflectances from individual measurements from channels 3 and 5 according to the Lambert cosine law and to average the calculations accumulated throughout a sustained period over time and area to yield the "cumulative quasi-global albedo."

Two specific modifications to the program (as it was used in the TIROS II, III, and IV analyses) were made for the TIROS VII degradation analysis (cf. References 1 and 47):

1. In the TIROS VII analyses the computer calculated daily averages from day 0 to day 38 and two-daily averages thereafter, instead of "cumulative" averages over sustained periods, which mask the true magnitude of the day by day changes in the instrument<sup>1, 47</sup>, and

2. In the TIROS VII analyses of channels 2 and 4 the computer averaged measurements of effective radiant emittance,  $\bar{W}$ , directly, instead of converting the measurements to total outgoing long-wave flux,  $W$ , which serves to mask the true magnitude of the instrumental degradation.<sup>1, 47</sup>

Except for these two modifications the program operated with minor modifications in the same way that it had for the previous TIROS satellites. A full discussion of this program and of the models which attempt to correct the degraded measurements is found in the "TIROS III Supplement<sup>47</sup>" and will not be repeated here.

Although this volume is concerned only with the first 1525 orbits (days 0-103), results from computer runs using data acquired within the first 380 days are shown in Figures 70-74. Data after day 103 become progressively more sparse in these Figures because much of the data is not yet reduced to the FMR tape format. However, the results available at this time are shown to indicate possible long-term fluctuations which may be

due to such factors as seasonal changes and the cyclic variations in the orbit—sun phase geometry (due to the regression of the orbital nodes and the opposing motion of the sun), rather than simply to instrumental degradation. Smoothed curves of the average quasi-global effective radiant emittance,  $\bar{W}_{ave}^i$ , and of the quasi-global albedo,  $A^i$ , are shown for the thermal channels (1, 2, and 4) and the reflected solar radiation channels (3 and 5) respectively vs. days after launch in Figures 70-74. Each of these Figures shows a more-or-less rapid decrease in the magnitude of its measurements with time. There remains the question of the absolute accuracies of the initial measurements in Figures 70-74, and this question must be answered before attempting to determine corrections to be applied to the measurements on the FMR tapes to account for degradation in the instrumental response (or for any other systematic factors contributing to the observed behavior of the experiment).

Of the five channels only channels 1 and 2 yield measurements in the first few days after launch in whose absolute values we have high confidence. Both of these channels showed stability in pre-launch checks-of-calibration and other tests and the validity of their calibrations have been confirmed by several post-launch studies. The validity of the initial measurements in the 14.8-15.5 micron region has been shown in papers by Bandeen et al.<sup>9</sup> and Nordberg et al.<sup>10</sup> The validity of the initial measurements in the 8-12 micron window has been confirmed by comparing the differences between climatological oceanic temperatures and channel 2  $T_{BB}$  measurements over clear skies with the estimated differences given by Wark et al.<sup>33</sup> In general the two differences compared within 5°K.

On the other hand the initial  $T_{BB}$  measurements by channel 4 appear to be definitely too high (i.e. approximately equal to the channel 2 measurements), and this offset is attributed to a shift in the oscillator connected with the unstable transistor and observed rise in the space-viewed level previ-

ously discussed (this characteristic is evident in the beginning of Figure 72). From Figures 73 and 74 the initial quasi-global albedos calculated from channels 3 and 5 are about 20%. This value is similar to those of the initial albedos measured by previous TIROS satellites<sup>1, 47</sup> and, for as yet unexplained reasons, is apparently much too low.

A recent study of the planetary heat balance, using selected portions of data from TIROS VII over a period of one year, compares the planetary albedo as inferred directly from channel 5 measurements with the albedo required by the total outgoing long-wave flux inferred from channel 2 measurements in combination with the assumption that planetary radiative equilibrium exists over the year.<sup>48</sup> Channels 2 and 5 were chosen over channels 4 and 3 for this study because the long term stability aspects of each of the former were superior to those of the latter. The conversion of the essentially beam measurements of channel 2 to total outgoing flux was accomplished by the method of Wark et al.,<sup>33</sup> and the data were extrapolated beyond latitudes 63.5° to each pole by paralleling the data given in the Northern hemispheric study of London.<sup>49</sup> Even after correcting the albedo values for the *apparent degradation* of channel 5 a planetary albedo of only 20.1% resulted. However, the albedo required by the long-wave measurements with the assumption of annual radiative equilibrium was 32.2%. The resulting ratio

$$\frac{32.2}{20.1} = 1.60 \quad (9)$$

then represents the *adjustment factor* by which channel 5 measurements must further be multiplied even after correcting for all *apparent degradation* (assuming that the long-wave measurements are correct). Albedo measurements from all previous TIROS satellites have seemingly been too low by approximately the same factor, 1.60, and it is interestingly close to 1.7, an "adjustment" factor suggested by Fritz et al.<sup>15</sup> for channel 3 of TIROS III in a study concerning atmospheric absorption of solar radiation.

A further characteristic pointed up by the planetary heat balance study is the marked cyclic variation occurring over each 76-day orbital synodic cycle (cf. Figure 66). In Figure 75, taken from the study,<sup>48</sup> the over-all averages of channel 2 effective radiant emittances over the globe between latitudes 63.5° N and S are shown for each of 19 weekly periods during the first year of TIROS VII (dots with bars). The 19 periods are numbered along the upper abscissa. The Roman numerals indicate the calendar months represented by groupings of four consecutive periods used in seasonal analyses. The orbit-sun phase geometry is shown by the sinusoid. For example, the solar meridian is over, respectively, the descending node, the southern-most point, the ascending node, and the northern-most point of the orbit at mid-week of periods 2, 3, 4, and 5, which also correspond to 29 June, 18 July, 6 August, and 25 August respectively (cf. Figure 66). All periods are similarly spaced every quarter synodic period (i.e. 19 days) except 1 which occurs immediately after launch, 19 which duplicates the geometry of 1 a year later, and 14 which was delayed 9 days because of solar interference in the short-wave channels when the sun was over the descending node. A least-squares quadratic curve is shown for these over-all "map averages." However, there are unavoidable gaps in the data coverage, caused by such factors as noise and engineering considerations preventing the successful acquisition and reduction of every possible orbit, which might bias the map averages. Upon close examination of the data, such biases were ascertained in the map averages of Figure 75. Therefore, averages of the  $\bar{W}$  values over an equatorial region of the Pacific Ocean which was uniformly covered by all 19 weekly maps were calculated and plotted (squares). The approximate boundaries of this area were 30°N, 150°W — 30°N, 120°W — 30°S, 150°W — 30°S, 180°. A least-squares quadratic fit for the Pacific Ocean averages is shown in Figure 75. This curve indicates virtually the same rate of degradation as the curve in Figure 71 and is interpreted as representing the

true instrumental degradation. An unmistakable cyclic pattern stands out in both types of data but especially in the Pacific Ocean averages. The highest values occur when the sun is over (or near) the descending node (i.e., periods 2, 6, 10, 14, and 17), with successive decreases over the following three periods. Only period 16 deviates from this pattern. The reason for this pattern is not clear at this time but is under investigation. From Figures 65, 66, and 75, it is seen that the highest values over the Pacific Ocean region occur near local midnight when viewing through the wall side only whereas the lowest values occur near local sunrise when viewing through both the floor and wall sides. If the lowest values over the Pacific Ocean had occurred one period earlier (i.e. near local noon when viewing through the floor side only) one would be tempted to conclude that there is a difference in the wall and floor calibrations. On the other hand one must be cautious in concluding that the variations are due *only* to diurnal meteorological effects (e.g. clouds) in view of the possibility of a difference between the floor and wall which does not manifest itself in an observed shift in the space-viewed level (cf. 6.2.1 below). The second-order corrections mentioned in Section 3.4 for the variations of  $T_c$  over an orbit were applied with the aid of Figures 17 and 18 and Figures 26-32 in producing the map averages and Pacific Ocean averages shown in Figure 75. These corrections amounted to about one-fifth of the observed periodic amplitudes in Figure 75 and actually served to *decrease* them slightly compared to the values calculated directly from the FMR tapes (where a mean value of  $T_c$  was assumed throughout each orbit in originally reducing the data). Thus the fluctuations of  $T_c$  over an orbital period cannot explain the 76-day periodicity of Figure 75. It is also evident from Figure 75 that such cyclic variations might be misinterpreted as being due to instrumental degradation in a shorter-lived satellite.

In comparing data from channels 2 and 4, the method developed by Wark et al.<sup>33</sup> for converting  $T_{BB}$  (or  $\bar{W}$ ) measurements from

these channels to total outgoing long-wave flux,  $\bar{W}$ , was utilized. Plots of  $\bar{W}$  vs.  $T_{BB}$  (and  $\bar{W}$ ) calculated for three zenith angles are shown in Figure 76 (specifically, the equations for TIROS III and TIROS IV given in the Supplement to MSL Report 10<sup>33</sup> were used). The following linear fits were adopted for comparing data from channels 2 and 4 of TIROS VII:

$$\text{Chan. 2} \dots \bar{W} = 98.35 + 6.32 \bar{W} \quad (10)$$

$$\text{Chan. 4} \dots \bar{W} = 20.79 + 4.92 \bar{W} \quad (11)$$

Because of the angular motion of the spin vector of TIROS over the celestial sphere<sup>44</sup> (Figure A-1), occasionally the 45° half-angle conical figure, generated by the radiometer axis in the wall direction as the satellite spins, intersects the direct rays of the sun. Under these conditions, direct solar radiation impinges upon the sensors from the wall direction momentarily once during each satellite rotation. Such an unfavorable satellite-sun geometry will exist until it is eliminated by a change in the attitude of the spacecraft. There were three periods in the history of TIROS VII between launch and September 30, 1963, when such an unfavorable geometry occurred, viz., the periods including the orbits numbered 0321-0343 (TIROS VII days 22 and 23), 0452-0562 (days 30-38), and 1401-1466 (days 95-99). When the direct solar radiation interference affects the long-wavelength channels the data are not reduced. However, in several orbits where there was no interference with the long-wavelength channels but interference with the short-wavelength channels only, the data were reduced. Data users should note that these "sun spikes" in the short-wavelength channels will produce erroneous values. Mapping of these data is especially misleading; however, one can recognize and eliminate these "sun spikes" from computer listings of the data.

**6.2.1 Channel 1** The history of  $\Delta F$  is shown in Figure 68a. The absolute magnitude of all values is less than 1 except for a few initial measurements which are only slightly greater than 1. Therefore the symmetrical optical degradation model<sup>47</sup> was used, assuming

that the smoothed curve in Figure 70 represents the true degradation of the instrumental response. The resulting correction nomogram is shown in Figure 77. These corrections are to be added to the wall and floor  $T_{BB}'$  measurements contained on the FMR tape. *In addition to the nomogram corrections there is evidence of another deviation from the original preflight calibration.* In a study of channel 1 data<sup>10</sup> it was found that measurements made over the same area a few minutes apart through the floor and the wall sides differed by varying amounts, generally from 4° to 6°K up to orbit 1525, with the measurements made through the floor being the higher. No consistent pattern has been detected, and we have as yet no satisfactory explanation for this effect. Such a difference between floor and wall measurements could readily be explained by the asymmetrical optical degradation model given in the "TIROS III Supplement"<sup>47</sup> *if negative-going pulses were observed. But no negative-going pulses are observed in the channel 1 data, and additional investigations are now under way attempting to explain this phenomenon.* Hence, for the lack of a better procedure at this time, we suggest increasing the wall measurements by an additional 2° to 3°K and decreasing the floor measurements by the same amount. For example, from Figure 77, it is seen that an equivalent blackbody temperature of 220°K measured by channel 1 during orbit 450 should be increased by 6°K, and further modified by 2.5°K, yielding a corrected wall measurement of  $220^\circ + 6^\circ + 2.5^\circ = 228.5^\circ\text{K}$  or a corrected floor measurement of  $220^\circ + 6^\circ - 2.5^\circ = 223.5^\circ\text{K}$ .

**6.2.2 Channel 2** The history of  $\Delta F$  is shown in Figure 68a. The absolute magnitude of all values is less than 1. Therefore, the symmetrical optical degradation model<sup>47</sup> was used, assuming that the smoothed curve in Figure 71 represents the true degradation of the instrumental response. The resulting correction nomogram is shown in Figure 78. These corrections are to be added to the wall and floor  $T_{BB}'$  measurements contained on the FMR tape. For example from Figure 78 it

is seen that an equivalent blackbody temperature of 260°K measured by channel 2 during orbit 1050 should be increased by 2°K, yielding a corrected measurement of 262°K.

**6.2.3 Channel 4** The history of  $\Delta F$  is shown in Figure 68a showing an initial value of +2.5 c.p.s. The lack of any "negative-going pulses" indicated that the degradation was at least partially electronic in nature, and the previous knowledge of an unstable oscillator transistor pointed to a shift in the frequency-voltage transfer function of that component. The compound degradation model was used in the initial degradation analysis in the manner described below.

From Figure 69 and equation (7) we can write

$$\bar{W}(T_{BB}) = \kappa^i [\bar{W}'(T_{BB}') + \rho^i] \quad (12)$$

where  $\rho^i = (-\Delta F/k)$ . From Figures 40-46 and Figure 9 a mean linearized curve of  $F_{sc}$  vs.  $\bar{W}$  was drawn, determining the value of  $k$ . The parameter,  $\rho^i$ , was determined using values of  $\Delta F$  from Figure 68a. The only remaining step was to determine  $\kappa^i$ , after which the equivalent blackbody temperature corrections  $\delta T_{BB} = T_{BB} - T_{BB}'$ , as a function of orbit number, were determined from equation (12) with the aid of Figure 9. It was assumed that the values of average quasi-global effective radiant emittance,  $\bar{W}_{ave}^i$ , from Figure 72 could be applied to equation (12), yielding

$$\bar{W}_{ave}^i (\text{undegraded}) = \kappa^i [\bar{W}_{ave}^i + \rho^i] \quad (13)$$

where  $\bar{W}_{ave}^i (\text{undegraded})$  refers to the value from Figure 72 which would be measured by an undegraded channel 4. It was decided to

"normalize"  $\bar{W}_{ave}^i (\text{undegraded})$  for channel 4 to its channel 2 counterpart (which was assumed to be undegraded on launch day) by means of equations (10) and (11). From

Figure 71 we have on launch day  $\bar{W}_{ave}^0 = 24.26$  watts/m<sup>2</sup>. Substituting this value in equation (10) and combining equations (10) and (11) we have

$$\begin{aligned} 98.35 + 6.32 (24.26) \\ = 20.79 + 4.92 \bar{W}_{ave}^i (\text{undegraded}) \end{aligned}$$

$$\bar{W}_{ave}^i \text{ (undegraded)} = \bar{W}_{ave}^{310} = 46.9 \text{ watts/m}^2 \quad (14)$$

where "310" refers to the orbit (on TIROS VII day 21) at which the curve of  $\bar{W}_{ave}^i$  in Figure 72 coincides with the "undegraded" value. This value agrees well with 47.1 watts/m<sup>2</sup>, the value at which the quadratic least-squares portion of the fit in Figure 72 (beyond day 30) intersects the ordinate if extrapolated backward. Substituting equation (14) in equation (13) we have

$$\kappa^i = 46.9 / [\bar{W}_{ave}^i + \rho^i] \quad (15)$$

Values of  $\kappa^i$  then were calculated by equation (15).

From Figure 68a the initially large value of  $\Delta F$  decreases and stabilizes at  $-0.7$  c.p.s. after only 70 orbits or 5 days (at which time the parameter  $\rho^i$  was set equal to zero and the degradation model became equivalent to the symmetrical optical degradation model<sup>47</sup>), but the time duration of rapidly changing slope in Figure 72 extends over the first 30 days before apparently becoming stabilized. This behavior is interpreted as indicating that a marked "rotation" as well as "translation" of the oscillator frequency-voltage prevailed at launch and that the translation of the space-viewed level diminished after only 5 days, whereas the rotation did not disappear for some 30 days, after which symmetrical optical degradation apparently predominated until about day 249. Beginning on day 249 an erratic "stepped" characteristic was observed in the space-viewed portions of analog presentations of channel 4 data. This peculiar behavior quite probably is still another manifestation of the known oscillator instability and interjects added doubt as to the validity of attempting to correct the channel 4 data after day 249.

The correction nomogram for channel 4 is shown in Figure 79. These corrections are to be added algebraically to the wall and floor  $T_{HB}'$  measurements contained on the FMR tape. For example, from Figure 79 it is seen that an equivalent blackbody temperature of 240°K measured by channel 4 during orbit 100 should be *decreased* by 3.4°K, yielding

a corrected measurement of 236.6°K.

**6.2.4 Channel 3** The history of  $\Delta F$  is shown in Figure 68b showing a continuing decrease to approximately orbit 550 after which  $\Delta F$  stabilizes at about  $-1.25$  c.p.s., indicating that a small amount of electronic degradation persists over most of the first 1525 orbits. Values of the quasi-global albedo were calculated assuming that all solar radiation was diffusely reflected according to the Lambert cosine law, and a least-squares quadratic curve was drawn through the data in Figure 73. The equation used was

$$A = \bar{W} / \bar{W}^* \cos \Theta_{\odot} \quad (16)$$

where  $\Theta_{\odot}$ , the solar zenith angle, was constrained within the limits  $0^\circ \leq \Theta_{\odot} \leq 60^\circ$ . The compound degradation model was used, and it was decided to "normalize" the data to the annual planetary albedo of 32.2% deduced from channel 2 and 5 data in Reference 48.

From Equations (7) and (16) and Figure 69 we have

$$\begin{aligned} A &= \frac{\bar{W}}{\bar{W}^* \cos \Theta_{\odot}} = \kappa^i \left[ \frac{\bar{W}' + \rho^i}{\bar{W}^* \cos \Theta_{\odot}} \right] = \\ &= \kappa^i \left[ A' - \frac{\Delta F}{k \bar{W}^* \cos \Theta_{\odot}} \right] \end{aligned} \quad (17)$$

Taking the mean value of  $\cos \Theta_{\odot}$  over many measurements as

$$\overline{\cos \Theta_{\odot}} = \frac{\int_0^{60^\circ} \cos \Theta_{\odot} d \Theta_{\odot}}{(60/57.296) \text{ radians}} = 0.827 \quad (18)$$

and taking the values

$$\begin{aligned} A_{ave} &= 0.322 \text{ (from Reference 48)} \\ A'_{ave} &= A^i \text{ (from Figure 73)} \\ k &= 0.147 \text{ c.p.s./watts m}^{-2} \text{ (from Figures 33-39)} \\ \bar{W}^* &= 484.36 \text{ watts/m}^2 \end{aligned}$$

we have, after substitution in equation (17),

$$\kappa^i = \left[ \frac{0.322}{A^i - \left( \frac{\Delta F}{58.88} \right)} \right] \quad (19)$$

Values of  $\kappa^i$  were calculated using Equation (19) and Figures 73 and 68b, values of  $\rho^i = (-\Delta F/k)$  were calculated, and both were plotted in the nomogram of Figure 80. From Figure 80 it is seen that the normalizing parameters for orbit 725 are  $\kappa^i = 1.89$  and  $\rho^i = +8.5 \text{ watts/m}^2$ , and that the normalized value of a measurement  $\bar{W}' = 50 \text{ watts/m}^2$  becomes

$$\begin{aligned}\bar{W} &= 1.89 [50 + 8.5] \\ &= 110.6 \text{ watts/m}^2\end{aligned}\quad (20)$$

**6.2.5 Channel 5** The history of  $\Delta F$  is shown in Figure 68b. The absolute magnitude of all values is less than 1. For generality the compound degradation model was used, although the small initial value of  $\rho^i$  rapidly diminished, and after orbit 70 it was set to zero (at which time the compound degradation model became equivalent to the symmetrical optical degradation model<sup>47</sup>).

With equation (18) and taking the values

$$A_{ave} = 0.322 \text{ (from Reference 48)}$$

$$A'_{ave} = A^i \text{ (from Figure 74)}$$

$$k = 0.675 \text{ c.p.s./watt m}^{-2}$$

$$\text{(from Figures 47-53)}$$

$$\bar{W}^* = 117.13 \text{ watts/m}^2$$

we have, after substitution in Equation (17),

$$\kappa^i = \left[ \frac{0.322}{A^i - \left( \frac{\Delta F}{65.38} \right)} \right] \quad (21)$$

Values of  $\kappa^i$  were calculated using Equation (21) and Figures 74 and 68b, and values of  $\rho^i = (-\Delta F/k)$  were calculated and plotted in the nomogram of Figure 81. In Figure 81 it is seen that the normalizing parameters for orbit 700 are  $\kappa^i = 1.65$  and  $\rho^i = 0 \text{ watts/m}^2$ , and that the normalized value of a measurement  $\bar{W}' = 10 \text{ watts/m}^2$  becomes

$$\bar{W} = 1.65 [10] = 16.5 \text{ watts/m}^2 \quad (22)$$

### 6.3 Estimate of the Accuracy of the Data

Inaccuracies in the data are caused not only by the degradation of the various channels after the original calibration, but also by such effects as wow and flutter in the magnetic tape, noise, drifts of  $T_E$  and  $T_C$  (and, after orbit 1276,  $T_V$ ) from their as-

sumed relationships, and uncertainties in the original calibration.

The estimates of accuracy given below apply to the mid-range of target intensities. It is evident from the figures of  $F_{SC}$  vs.  $T_{BB}$  that the accuracy of the thermal channels suffers at very low target temperatures.

**6.3.1 Channel 1.** The estimated short-term relative accuracy of  $T_{BB}$  measurements from a given side (floor or wall) is  $\pm 2^\circ K$ , and the estimated absolute accuracy is  $\pm 7^\circ K$  after applying corrections from Figure 77.

**6.3.2 Channel 2.** The estimated short-term relative accuracy of  $T_{BB}$  measurements from a given side is  $\pm 2^\circ K$ , and the estimated absolute accuracy is  $\pm 5^\circ K$  after applying corrections from Figure 78.

**6.3.3 Channel 4.** The estimated short-term relative accuracy of  $T_{BB}$  measurements from a given side is  $\pm 2^\circ K$ , and the estimated absolute accuracy is  $\pm 8^\circ K$  after applying corrections from Figure 79.

**6.3.4 Channel 3 and Channel 5.** The estimated short-term relative accuracy of  $\bar{W}$  measurements is  $\pm 10 \text{ watts/m}^2$  and  $\pm 2 \text{ watts/m}^2$  respectively for channels 3 and 5. Because of the lack of a satisfactory explanation for the adjustment factor (of the order of 1.60) by which channel 3 and 5 measurements of all TIROS satellites have seemingly been too low, no estimates of absolute accuracy are given.

### 6.4 Comments on Significant Engineering Aspects of the Experiment

In the preceding paragraphs, the behavior of the radiometer has been described in detail. In the following paragraphs a summary will be given of other types of behavior which affected the radiation data or their coverage.

Tiros VII had been in orbit only 39 days (orbit 573) when a malfunction developed in the playback mode (described in Section 4.1), requiring two playbacks to recover the data. The nature of the two-playback operation resulted in the loss of some data at the beginning of each orbit. The amount of data lost was variable but generally quite small.

As pointed out in Section 4.3, the sampling



rate used in digitizing the data at the Data Processing Center was doubled on TIROS VII day 73 (orbit 1080), providing twice as many measurements per unit time on the FMR tapes.

The Fairbanks, Alaska, Command and Data Acquisition station started to operate on Day 83, acquiring data from orbit 1230 as its first interrogation. The addition of the Fairbanks station did not, in general, provide for the acquisition of additional data than was previously provided by the Wallops and San Nicolas stations. However, on rare occasions the Fairbanks station acquired the fifth orbit of the nine orbit series which comprises an interrogation day. The fifth orbit could never be acquired by either Wallops or San Nicolas.

Beginning with the interrogation day for Tiros VII Day 87, the channel 6 commutator (described in Section 4.1) failed to switch and remained set on the electron temperature probe sensor. Thus, the radiometer housing temperature, among other elements, was not received from the satellite. As a consequence the housing temperature was derived from the TV clock number 2 temperature (described in Section 3.4).

## VII. CONCLUSIONS

The major limitation of the TIROS VII medium resolution radiometer experiment is the uncertainty in the absolute values of the measurements, resulting from the degradation of the radiometer response and, also, from electronic degradation which, for the first time, was conclusively detected in TIROS VII. The degradation corrections given in Section VI can serve as a guide for interpreting the data in terms of absolute values. However, it must be emphasized that these corrections are only our best estimates, based upon certain simplifying assumptions, of the effects of a complicated degradation mechanism which we do not yet fully understand, and that the measurements thus corrected may still contain appreciable uncertainties.

Because of the extended lifetime of the radiometer, which as of this writing exceeds fifteen months, the potential of the TIROS VII radiometric data for climatological studies is significantly greater than it was for previous TIROS satellites. In utilizing the measurements over extended periods, however, channel 2 and 5 data should be used in lieu of channel 4 and 3 data respectively wherever possible because of the superior stability characteristics of the former two channels.

The data from all channels are of value throughout the period covered by this Volume for studies involving relative measurements over a short period of time, for example the contrast mapping of cloud systems.

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TABLE III—Filter and Lens Materials

	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5
Lens 1	KRS-5 (Thallium-bromo-iodide) with no coatings.	Germanium with both surfaces coated with pure ZnS of $\lambda/4$ optical thickness at $10\mu$ .	Synthetic Barium Fluoride ( $\text{BaF}_2$ ) with no coatings.	KRS-5 (Thallium-Bromo-iodide) with no coatings.	Pure quartz ( $\text{SiO}_2$ ) with no coatings.
Lens 2	None -----	Germanium with both surfaces coated with ZnS of $\lambda/4$ optical thickness at $10\mu$ .	Synthetic Sapphire ( $\text{Al}_2\text{O}_3$ ) with no coatings.	None -----	Synthetic Sapphire ( $\text{Al}_2\text{O}_3$ ) with no coatings.
Filter 1	OCLI Band Pass Filter centered at $15.2\mu$ with half amplitude at $14.8\mu$ and $15.6\mu$ .	Indium Antimonide ( $\text{InSb}$ ) with both surfaces coated with pure ZnS of $\lambda/4$ optical thickness at $10\mu$ .	None -----	Indium Antimonide ( $\text{InSb}$ ) coated with pure ZnS, one surface with $\lambda/4$ optical thickness at $13\mu$ and the other at $20\mu$ .	OCLI Band Pass Filter centered at $0.6\mu$ with half amplitude at $0.56\mu$ and $0.72\mu$ .
Filter 2	None -----	Arsenic Trisulfide ( $\text{As}_2\text{S}_3$ ) glass, uncoated 0.5 mm plane piece.	None -----	None -----	None -----

TABLE IV—Effective Spectral Response, Channel 1

$\lambda (\mu)$	$\phi_\lambda$	$\lambda (\mu)$	$\phi_\lambda$
14.00	0	15.25	.1798
14.10	.0040	15.30	.1730
14.20	.0040	15.37	.1400
14.30	.0081	15.40	.1232
14.40	.0200	15.50	.0820
14.50	.0286	15.60	.0658
14.60	.0410	15.70	.0409
14.70	.0575	15.80	.0326
14.80	.0822	15.90	.0164
14.90	.1152	16.00	.0122
15.00	.1575	16.10	.0082
15.10	.1823	16.20	.0082
15.13	.1863	16.30	0
15.20	.1904		

TABLE VI—Effective Spectral Response, Channel 3

$\lambda (\mu)$	$\phi_\lambda$	$\lambda (\mu)$	$\phi_\lambda$
.24	.0119	.65	.3074
.25	.0302	.70	.2969
.26	.0681	.75	.3031
.27	.1123	.80	.2904
.28	.1587	.85	.2984
.29	.1784	.90	.3145
.30	.2296	.95	.3318
.31	.2548	1.00	.3802
.32	.2785	1.50	.4460
.33	.2949	2.00	.4777
.34	.3075	2.50	.5182
.35	.3260	3.00	.5001
.36	.3331	3.50	.5319
.37	.3588	4.00	.5304
.38	.3643	4.50	.4957
.39	.3689	5.00	.4564
.40	.3686	5.50	.2869
.45	.3570	6.00	.1716
.50	.3505	6.50	.0188
.55	.3272	7.00	0
.60	.3285		

TABLE V—Effective Spectral Response, Channel 2

$\lambda (\mu)$	$\phi_\lambda$	$\lambda (\mu)$	$\phi_\lambda$
7.5	0	14.5	.0080
8.0	.1094	15.0	.0081
8.5	.1960	15.5	.0164
9.0	.2535	16.0	.0410
9.5	.2662	16.5	.0660
10.0	.2627	17.0	.0695
10.5	.2512	17.5	.0672
11.0	.2534	18.0	.0411
11.5	.2266	18.5	.0370
12.0	.1908	19.0	.0246
12.5	.1749	19.5	.0164
13.0	.1193	20.0	.0082
13.5	.0402	20.5	.0082
14.0	.0080	21.0	0.0

TABLE VII—Effective Spectral Response, Channel 4

$\lambda (\mu)$	$\phi_\lambda$	$\lambda (\mu)$	$\phi_\lambda$	$\lambda (\mu)$	$\phi_\lambda$
7.0	.0000	16.5	.2873	26.0	.1535
7.5	.0141	17.0	.2853	26.5	.1389
8.0	.1392	17.5	.2766	27.0	.1295
8.5	.1627	18.0	.2794	27.5	.1068
9.0	.1887	18.5	.2732	28.0	.0886
9.5	.2021	19.0	.2691	28.5	.0828
10.0	.1994	19.5	.2608	29.0	.0768
10.5	.2058	20.0	.2425	29.5	.0678
11.0	.2119	20.5	.2356	30.0	.0586
11.5	.2236	21.0	.2285	30.5	.0606
12.0	.2406	21.5	.2214	31.0	.0411
12.5	.2389	22.0	.2118	31.5	.0310
13.0	.2556	22.5	.2041	32.0	.0274
13.5	.2689	23.0	.1914	32.5	.0210
14.0	.2742	23.5	.1758	33.0	.0385
14.5	.2821	24.0	.1667	33.5	.0210
15.0	.2850	24.5	.1657	34.0	.0133
15.5	.2877	25.0	.1623	34.5	.0190
16.0	.2848	25.5	.1602	35.0	.0138

TABLE VIII—Effective Spectral Response,  
Channel 5

$\lambda$ ( $\mu$ )	$\phi_\lambda$	$\lambda$ ( $\mu$ )	$\phi_\lambda$
.50	.0041	.90	.0182
.52	.0234	.92	.0088
.54	.1077	.94	.0054
.56	.2922	.96	.0085
.58	.3419	.98	.0025
.60	.3496	1.00	.0015
.62	.3398	1.02	.0012
.64	.3084	1.50	0.0
.66	.2692	1.60	.0045
.68	.2377	1.70	.0092
.70	.2105	1.80	.0093
.72	.1757	1.90	.0094
.74	.1488	2.00	.0057
.76	.1304	2.10	.0089
.78	.1000	2.20	.0089
.80	.0761	2.30	.0050
.82	.0541	2.40	.0105
.84	.0379	2.50	.0123
.86	.0266	2.60	.0144
.88	.0183	2.70	0.0

TABLE X— $T_{BB}$  vs.  $\bar{W}$ , Channel 2

$T_{BB}$ ( $^{\circ}$ K)	$\bar{W}$ (watts/m <sup>2</sup> )
77.0	.0011
97.0	.0126
117.0	.0721
137.0	.2752
157.0	.7960
177.0	1.884
197.0	3.837
217.0	6.966
237.0	11.56
257.0	17.88
277.0	26.12
297.0	36.42
317.0	48.86

TABLE IX— $T_{BB}$  vs.  $\bar{W}$ , Channel 1

$T_{BB}$ ( $^{\circ}$ K)	$\bar{W}$ (watts/m <sup>2</sup> )
160	.1821
180	.3528
200	.6000
220	.9283
240	1.338
260	1.827
280	2.391
300	3.024

TABLE XI— $T_{BB}$  vs.  $\bar{W}$ , Channel 4

$T_{BB}$ ( $^{\circ}$ K)	$\bar{W}$ (watts/m <sup>2</sup> )
160	4.916
180	8.927
200	14.748
220	22.665
240	32.901
260	45.617
280	60.911
300	78.829
320	99.368

TABLE XII—Changes in Blackbody Temperature ( $T_{BB}$ ) and Effective Radiant  
Emittance ( $\bar{W}$ ) Due to Differences of  $T_C$  from  $T_E$ 

Channel	Side	$T_E$ ( $^{\circ}$ C)	$T_C$ ( $^{\circ}$ C)	$F_{sc}$ (cps)	$T_{BB}$ ( $^{\circ}$ K)	$\Delta T_{BB}$	$\bar{W}$ (w/m <sup>2</sup> )	$\bar{W}/\bar{W}^*$	$\Delta(\bar{W}/\bar{W}^*)$
1	Floor	0	0	370.0	203.7				
		7	0	370.25	204.7	1.0			
		7	7	370.0	201.7				
	Wall	0	7	369.75	200.7	1.0			
		0	0	370.0	207.2				
		7	0	370.25	208.2	1.0			
		7	7	370.0	205.7				
2	Floor	0	7	369.75	204.7	1.0			
		0	0	185.0	263.2				
		7	0	185.2	363.4	0.2			
	Wall	7	7	185.0	258.7				
		0	7	184.8	258.5	0.2			
		0	0	185.0	261.7				
		7	0	185.2	261.9	0.2			
3	Floor	7	7	185.0	254.2				
		0	7	184.8	254.0	0.2			
		0	0	258.0			166	0.3356	
	Wall	7	0	258.5			167	0.3397	.0041
		7	7	258.0			152	0.3138	
		0	7	257.5			150	0.3097	.0041
		0	0	258.0			164	0.3386	
4	Floor	7	0	258.5			167	0.3448	0.0060
		7	7	258.0			150	0.3097	
		0	7	257.5			148	0.3056	0.0041
	Wall	0	0	325.0	271.7				
		7	0	325.2	272.0	0.3			
		7	7	325.0	264.5				
		0	7	324.8	264.2	0.3			
5	Floor	0	0	325.0	269.2				
		7	0	325.2	269.5	0.3			
		7	7	325.0	262.4				
	Wall	0	7	324.8	262.0	0.4			
		0	0	130.0			40	0.3415	
		7	0	130.25			40.5	0.3458	0.0048
		7	7	130.0			37.5	0.3202	
6	Floor	0	7	129.75			37.0	0.3159	0.0048
		0	0	130.0			40	0.3415	
		7	0	130.25			40.5	0.3458	0.0048
	Wall	7	0	130.0			37.5	0.3202	
		7	7	130.0			37.0	0.3159	0.0048
		0	7	129.75					
		0	0						

TABLE XIII—Vertical Alignment Check of the Various Channels of TIROS VII Radiometer

	CHANNEL—1			CHANNEL—2			CHANNEL—3			CHANNEL—4			CHANNEL—5		
	DEG	MIN	SEC	DEG	MIN	SEC	DEG	MIN	SEC	DEG	MIN	SEC	DEG	MIN	SEC
Right Edge (top) Field of View	231	51	36.5	228	23	53.5	230	22	12.5	231	35	41.5	230	0	28
Left Edge (Bottom) Field of View	220	33	17	220	50	26	221	46	6	223	35	47	224	29	29.5
Total Field of View	11	18	19.5	7	33	27.5	8	36	6.5	7	59	54.5	5	30	58.5
Base Angle	181	22	35.5	181	22	35.5	181	22	35.5	181	22	35.5	181	22	35.5
(Computation)															
Left Edge Field of View	220	33	17	220	50	26	221	46	6	223	35	47	224	29	29.5
Minus Base Angle	—181	22	35.5	—181	22	35.5	—181	22	35.5	—181	22	35.5	—181	22	35.5
Plus ½ field of View	39	10	41.5	39	27	50.5	40	23	30.5	42	13	11.5	43	6	54
= Optical axis with respect to Base Plate	+5	39	10	+3	46	44	+4	48	3	+3	59	57	+2	45	29
Error Angle from Optimum 45°	44	49	51.5	43	14	34.5	45	11	33.5	46	13	8.5	45	52	23
	—0	10	8.5	—1	45	25.5	+0	11	33.5	+1	13	8.5	+0	52	23
Noise Voltage	1.35 VDC			.40 VDC			.41 VDC			.70 VDC			.36 VDC		

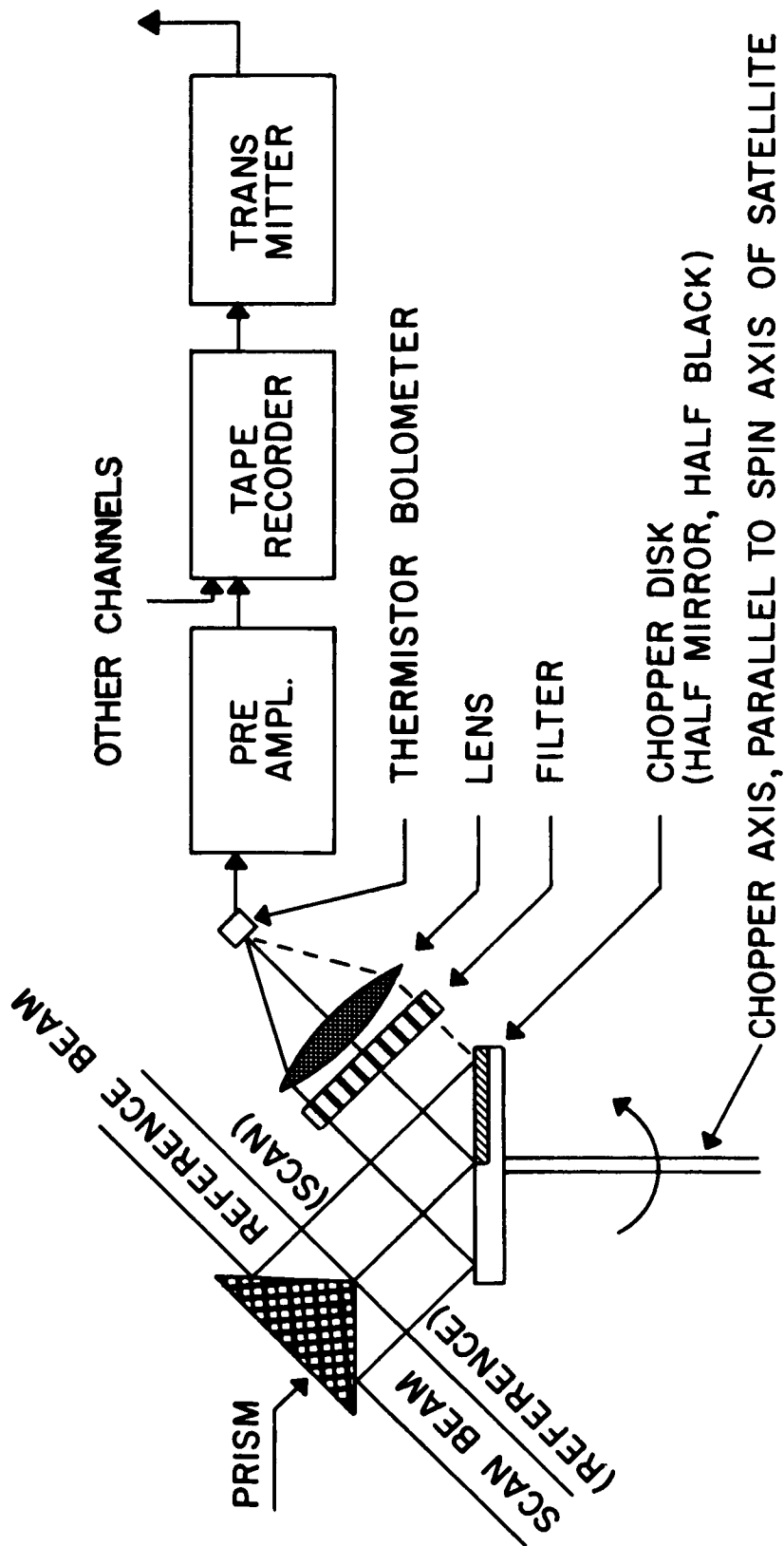


Figure 1—Block diagram of one channel of the medium resolution radiometer.

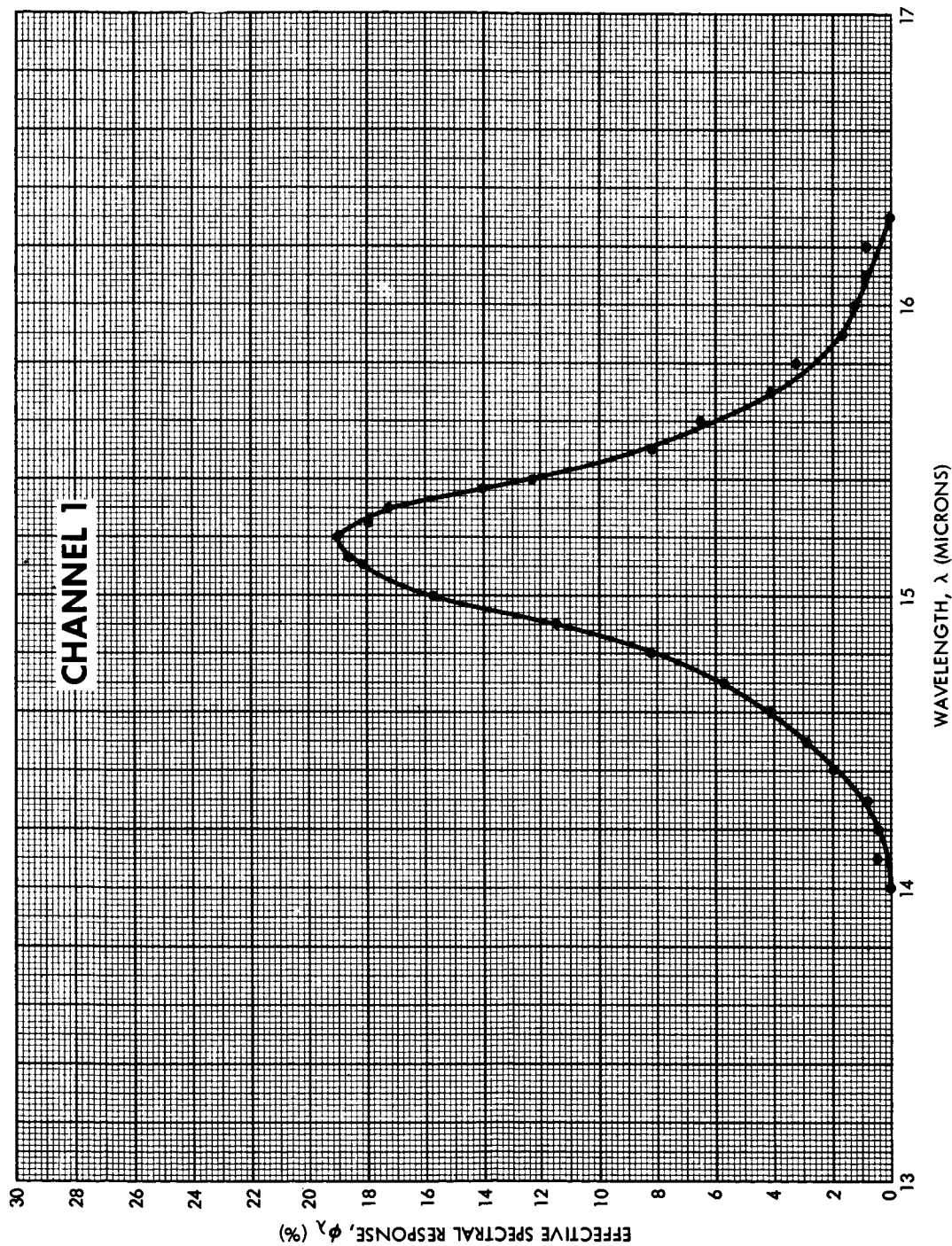


Figure 2—The effective spectral response of channel 1 versus wavelength.



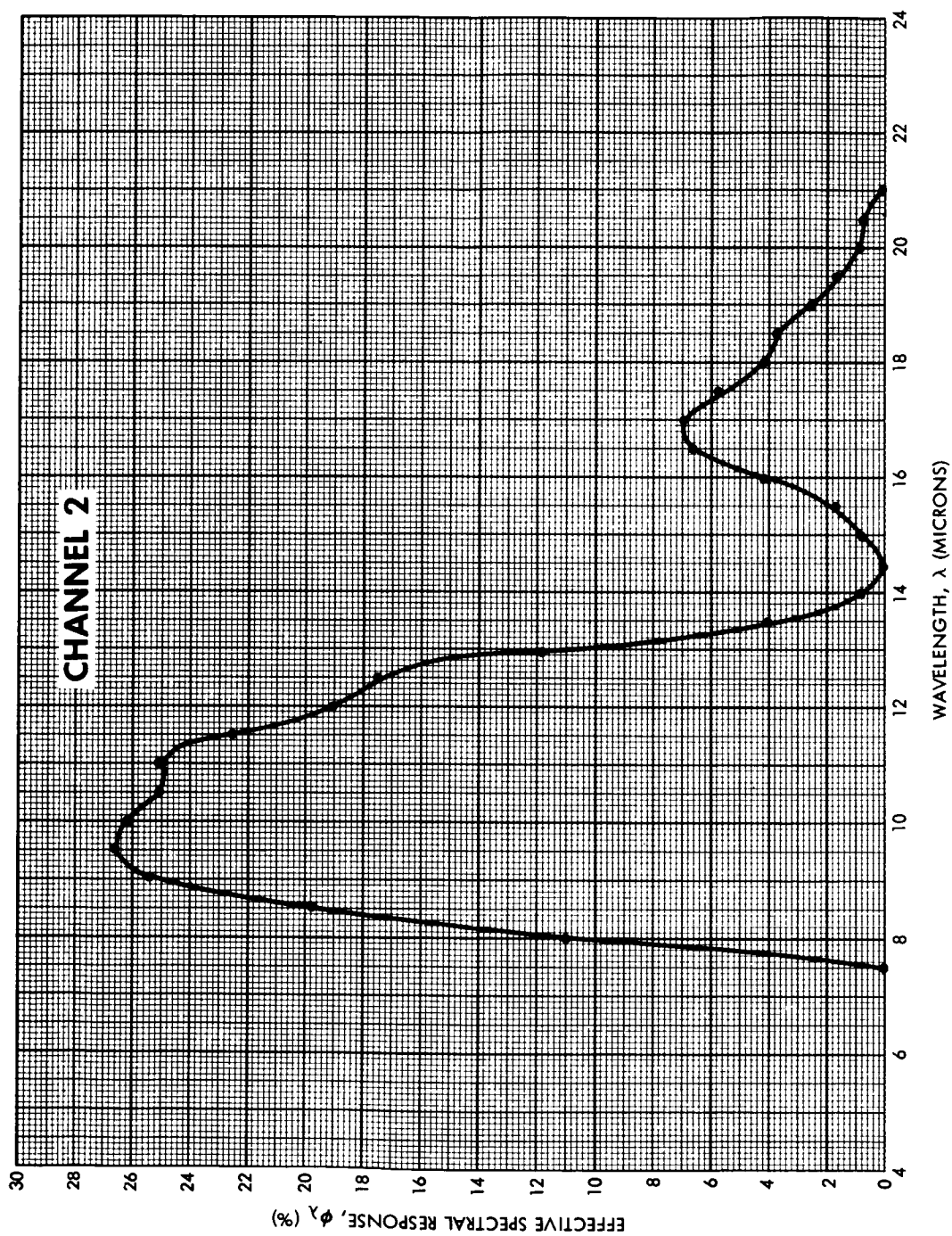


Figure 3—The effective spectral response of channel 2 versus wavelength.

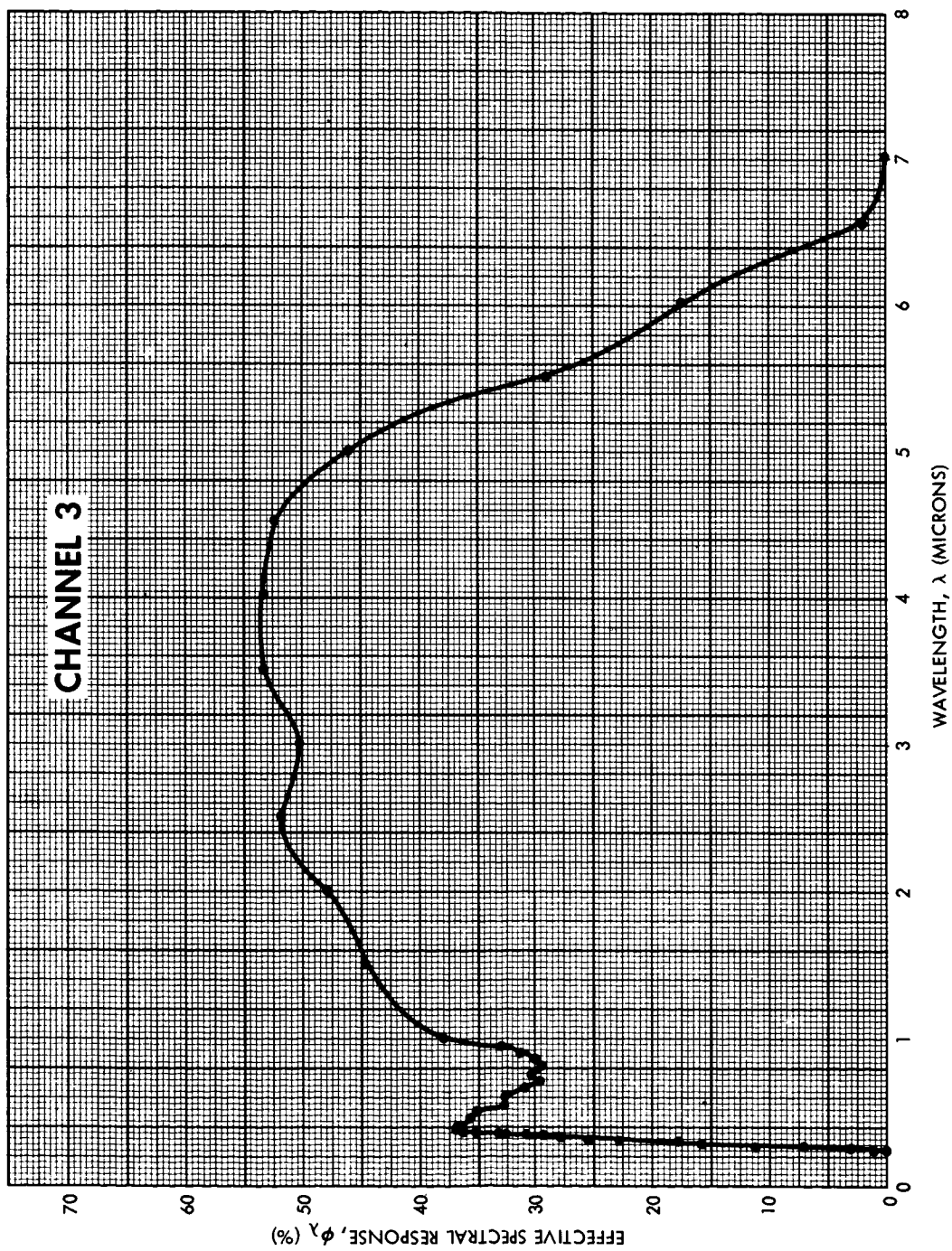


Figure 4—The effective spectral response of channel 3 versus wavelength.

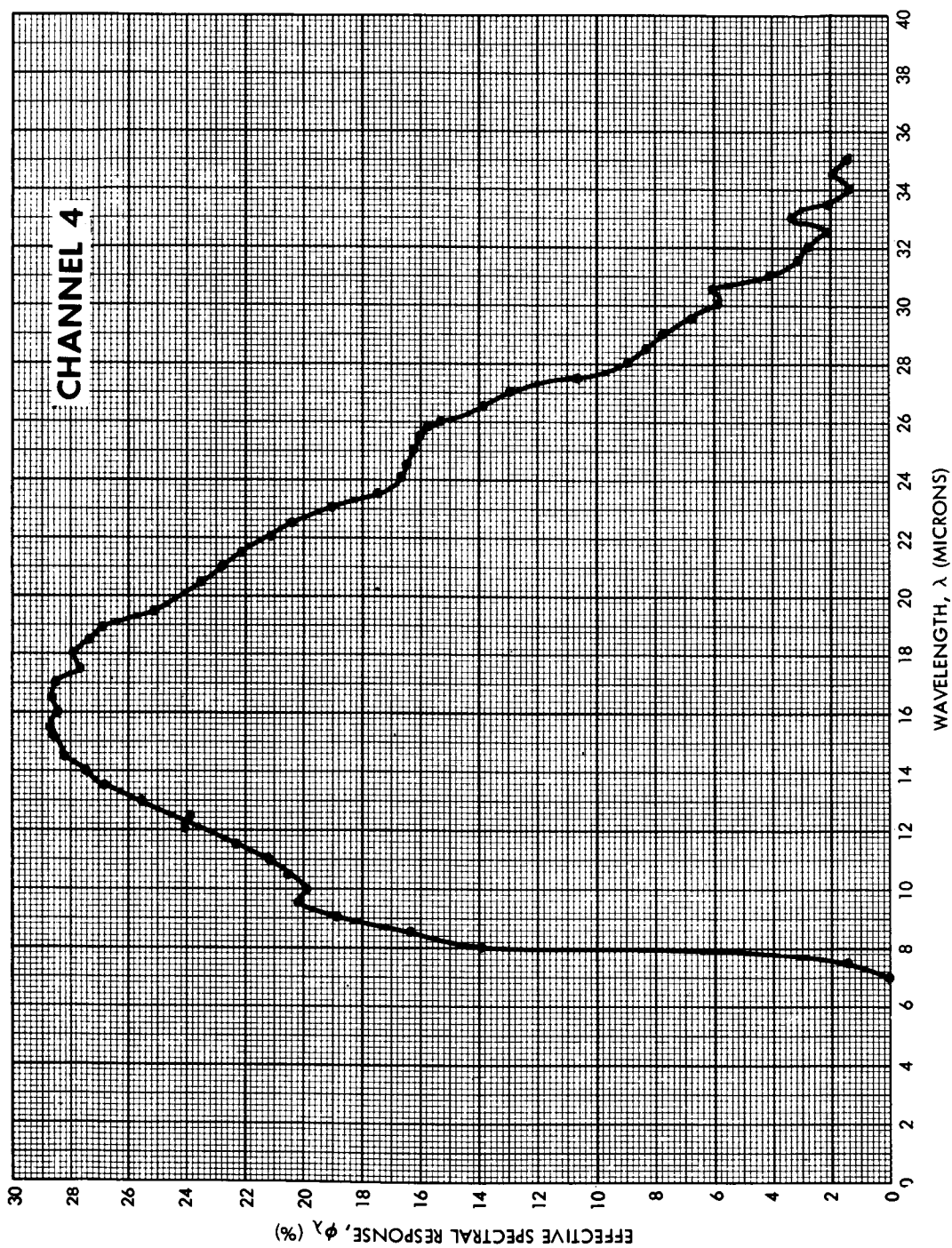


Figure 5—The effective spectral response of channel 4 versus wavelength.

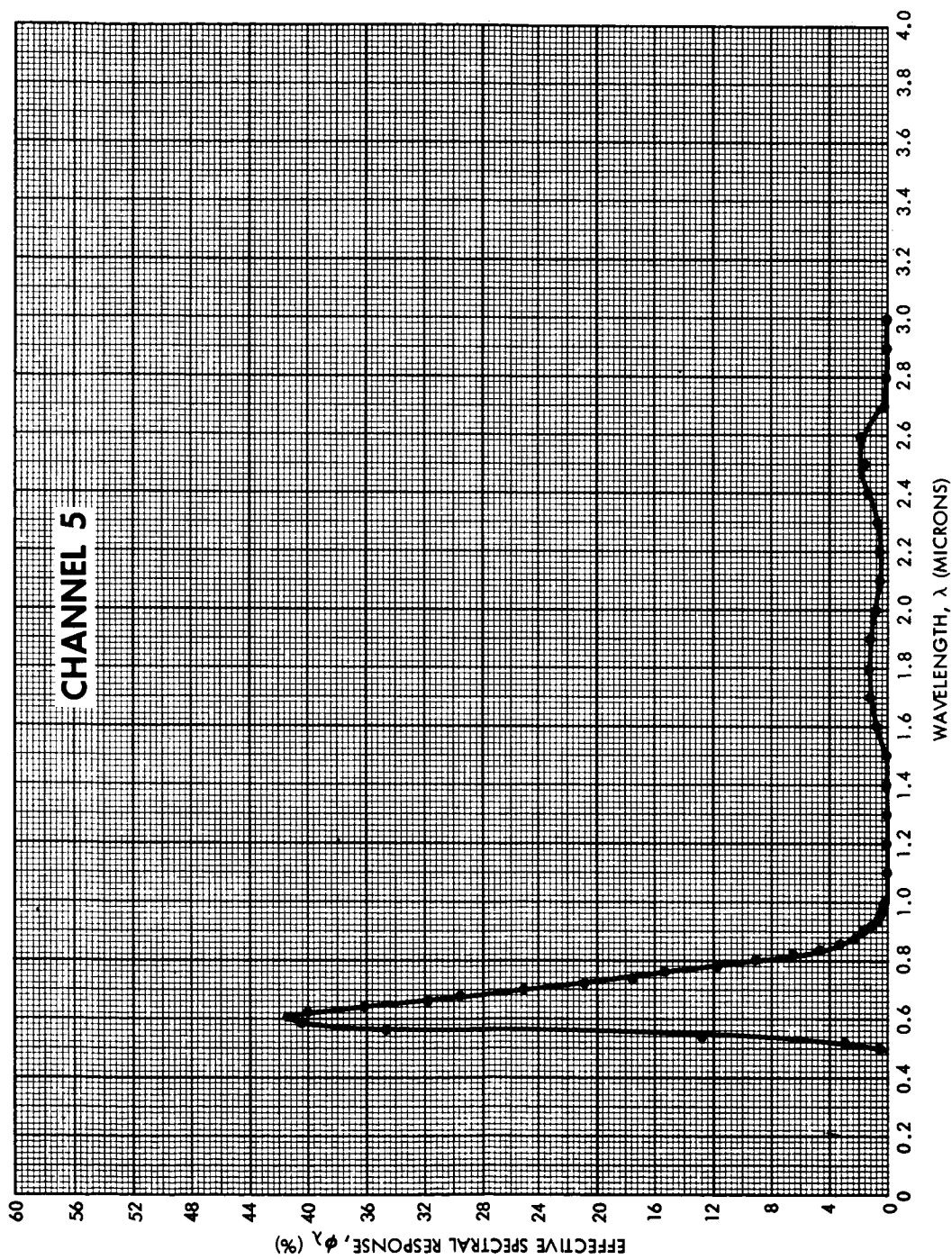


Figure 6—The effective spectral response of channel 5 versus wavelength.

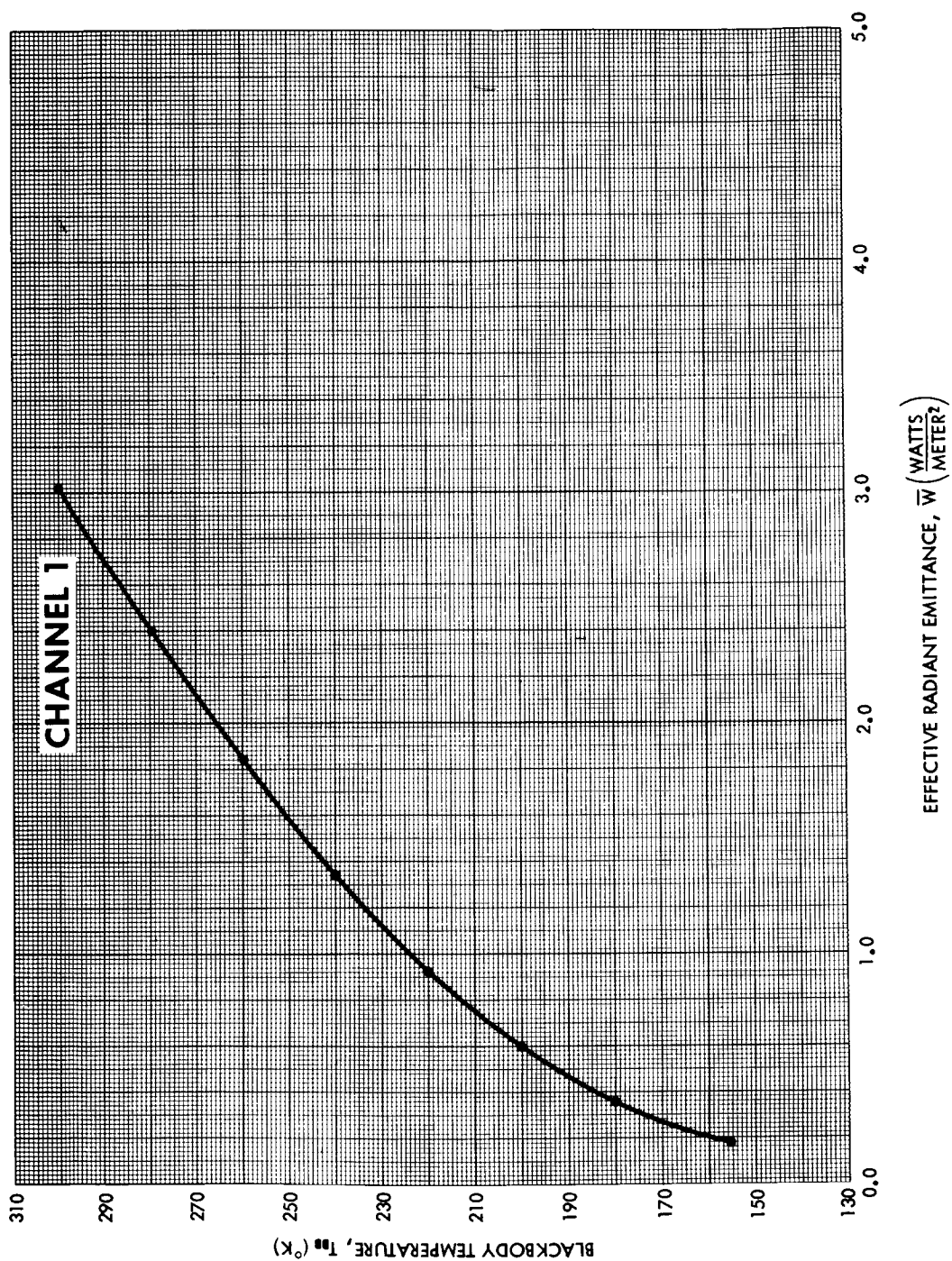


Figure 7—The equivalent blackbody temperature versus effective radiant emittance for channel 1.



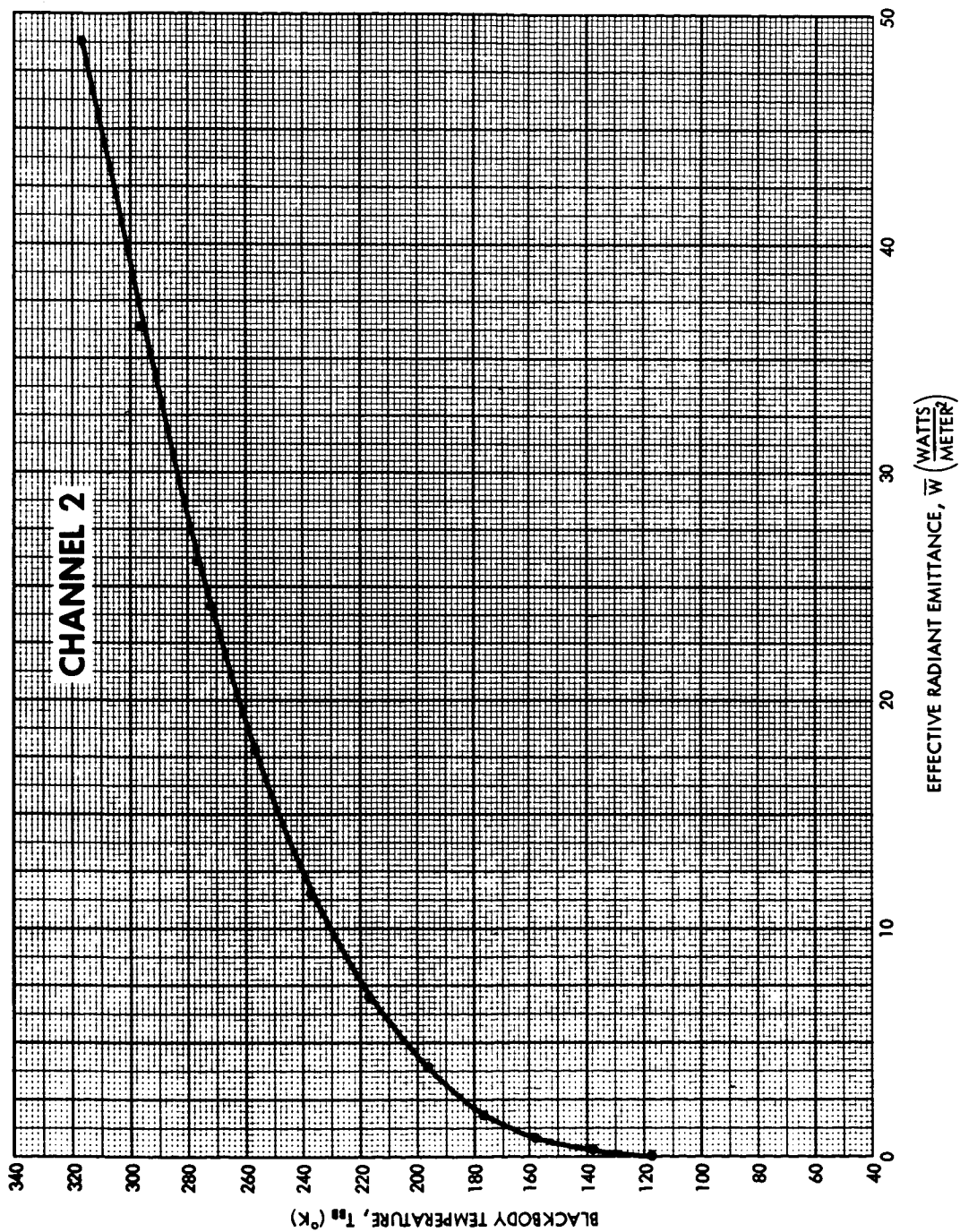


Figure 8—The equivalent blackbody temperature versus effective radiant emittance for channel 2.

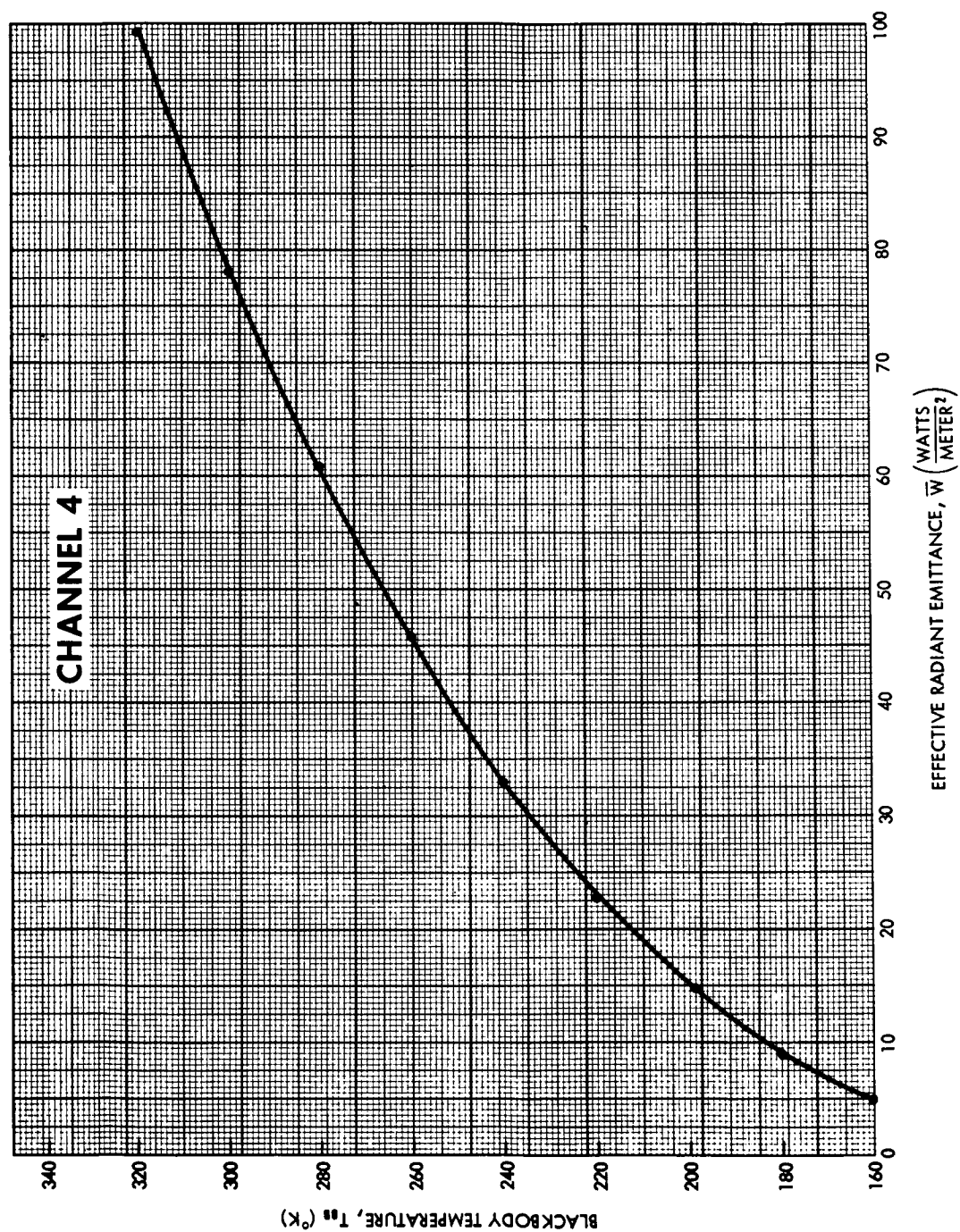


Figure 9—The equivalent blackbody temperature versus effective radiant emittance for channel 4.

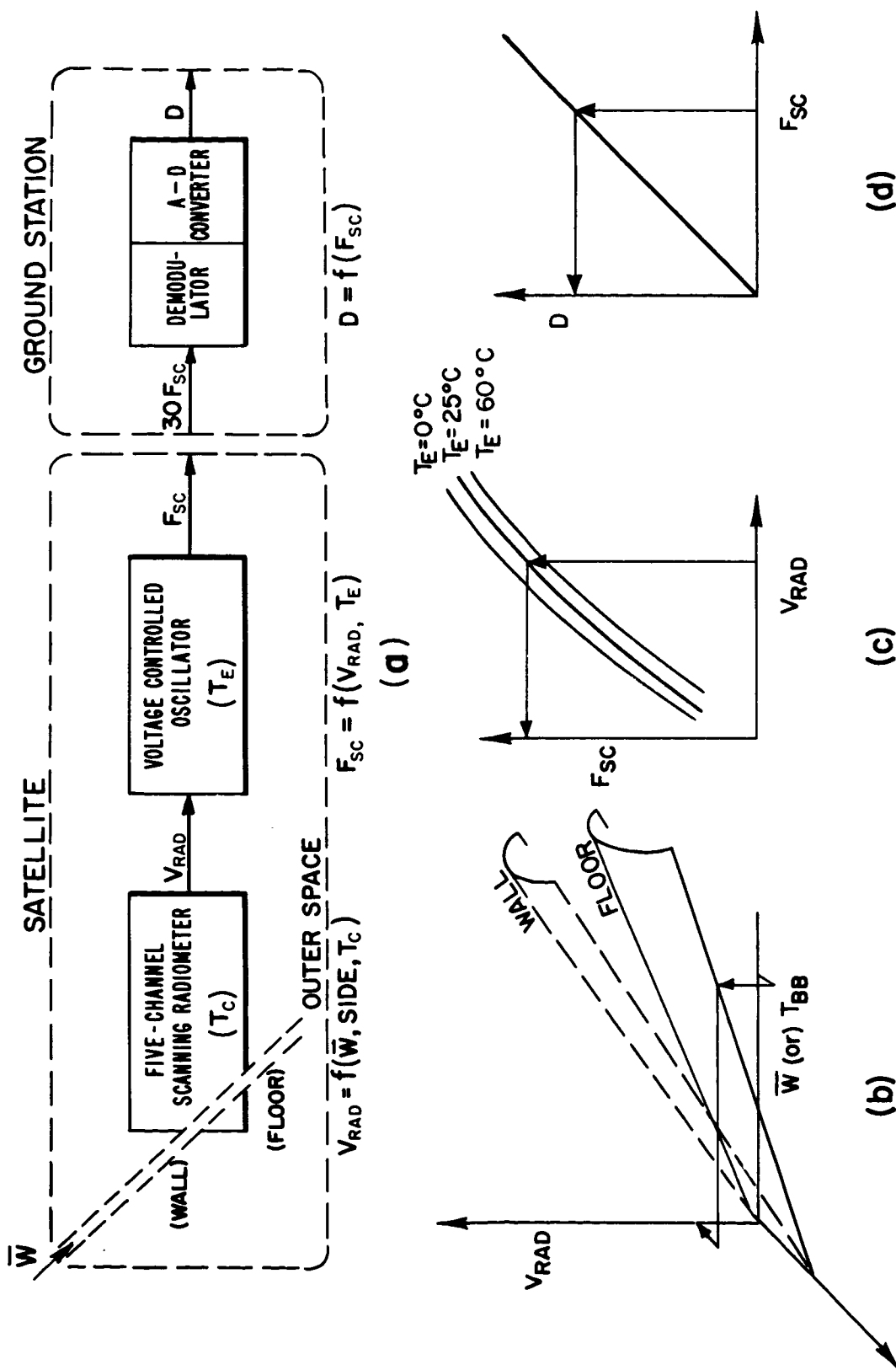


Figure 10—(a) Schematic representation of transfer functions associated with instrumentation in the satellite and at the ground station. (b) Three-dimensional representation of the response of the five-channel scanning radiometer. (c) The response of the voltage controlled oscillator shown as a parametric function of the electronics temperature,  $T_E$ . (d) Conversion from subcarrier frequency to digital number.



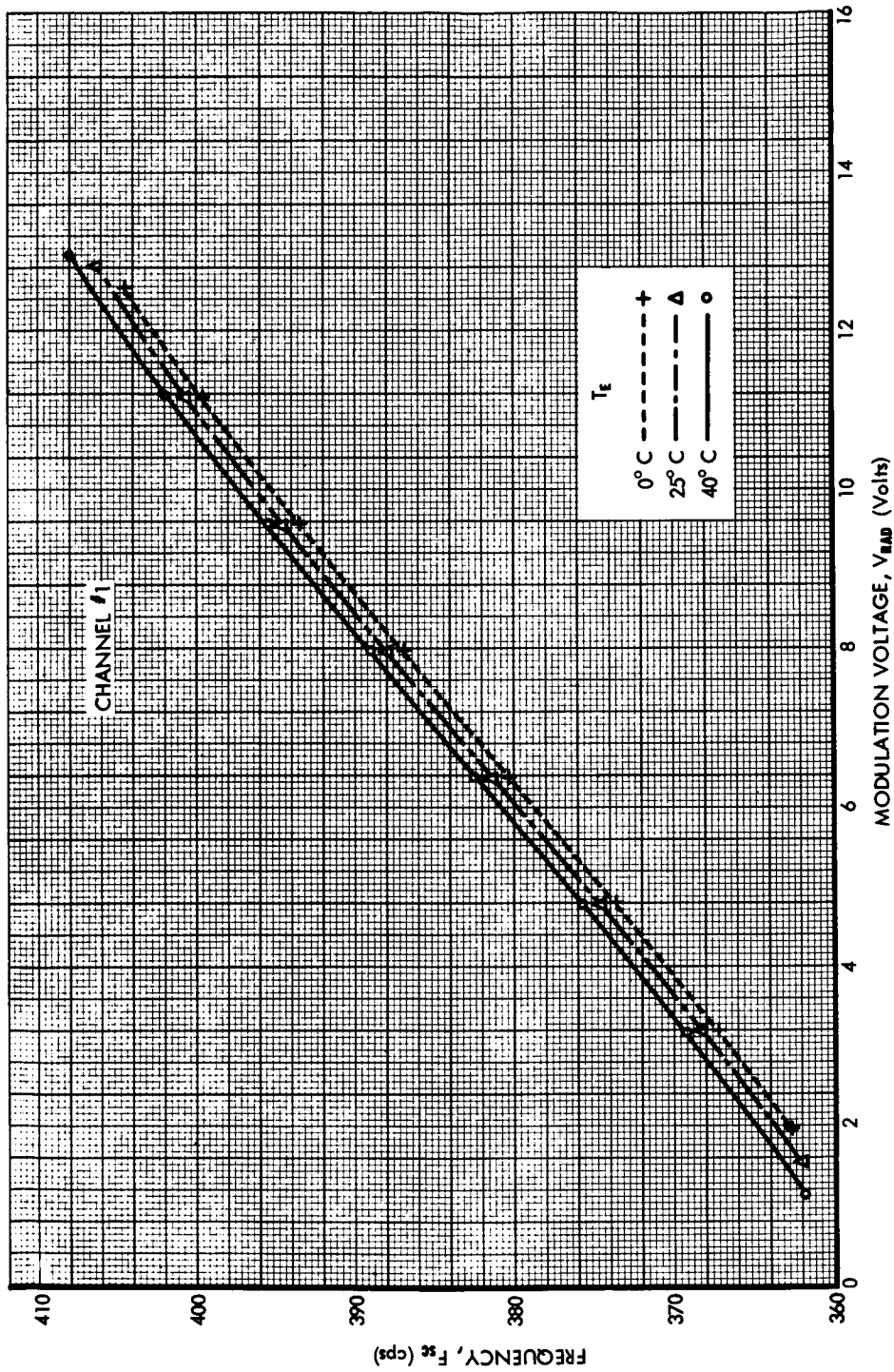


Figure 11—The response of the voltage controlled oscillator for channel 1 shown as a parametric function of the electronics temperature,  $T_e$ .

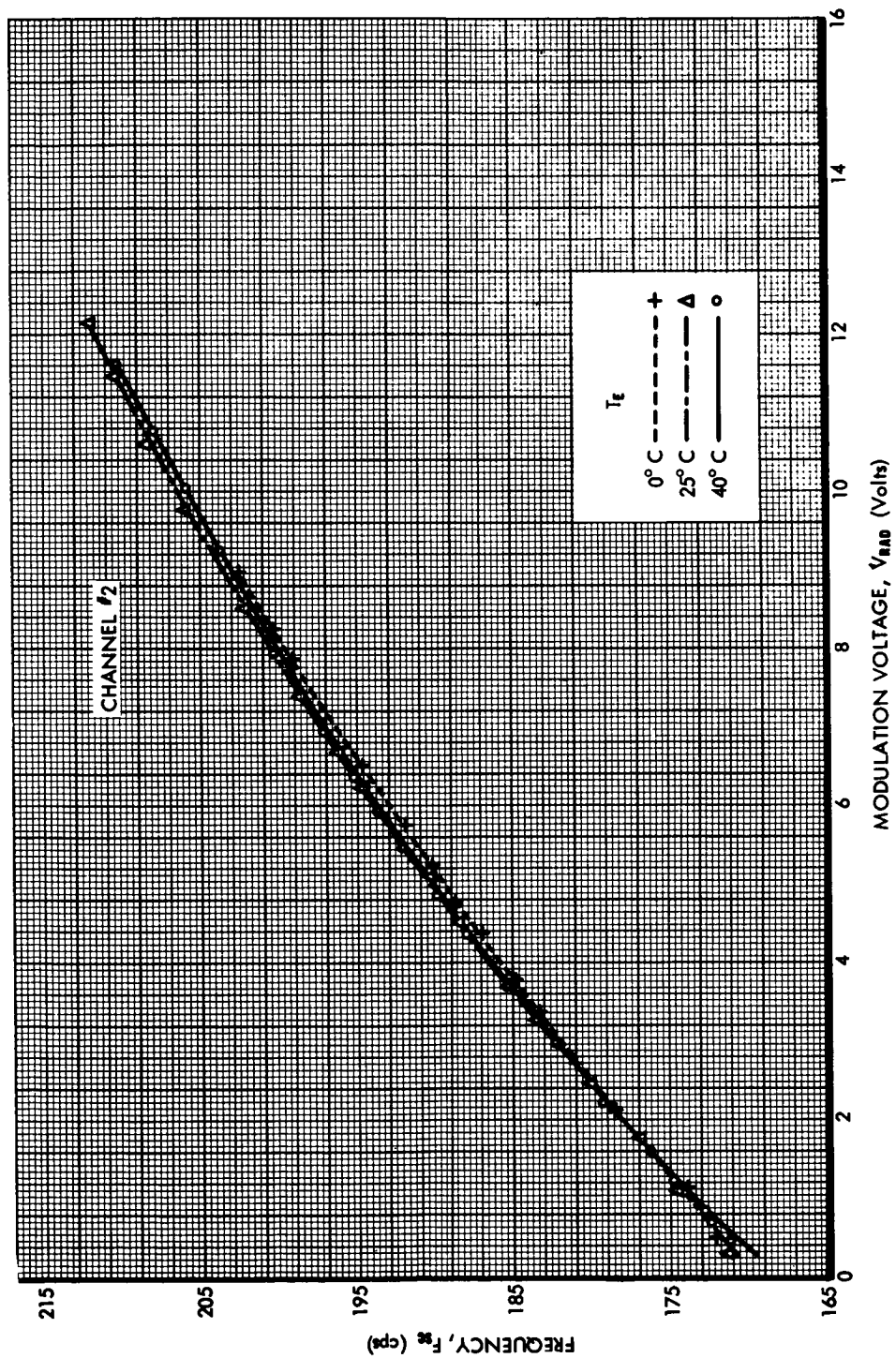


Figure 12—The response of the voltage controlled oscillator for channel 2 shown as a parametric function of the electronics temperature,  $T_e$ .

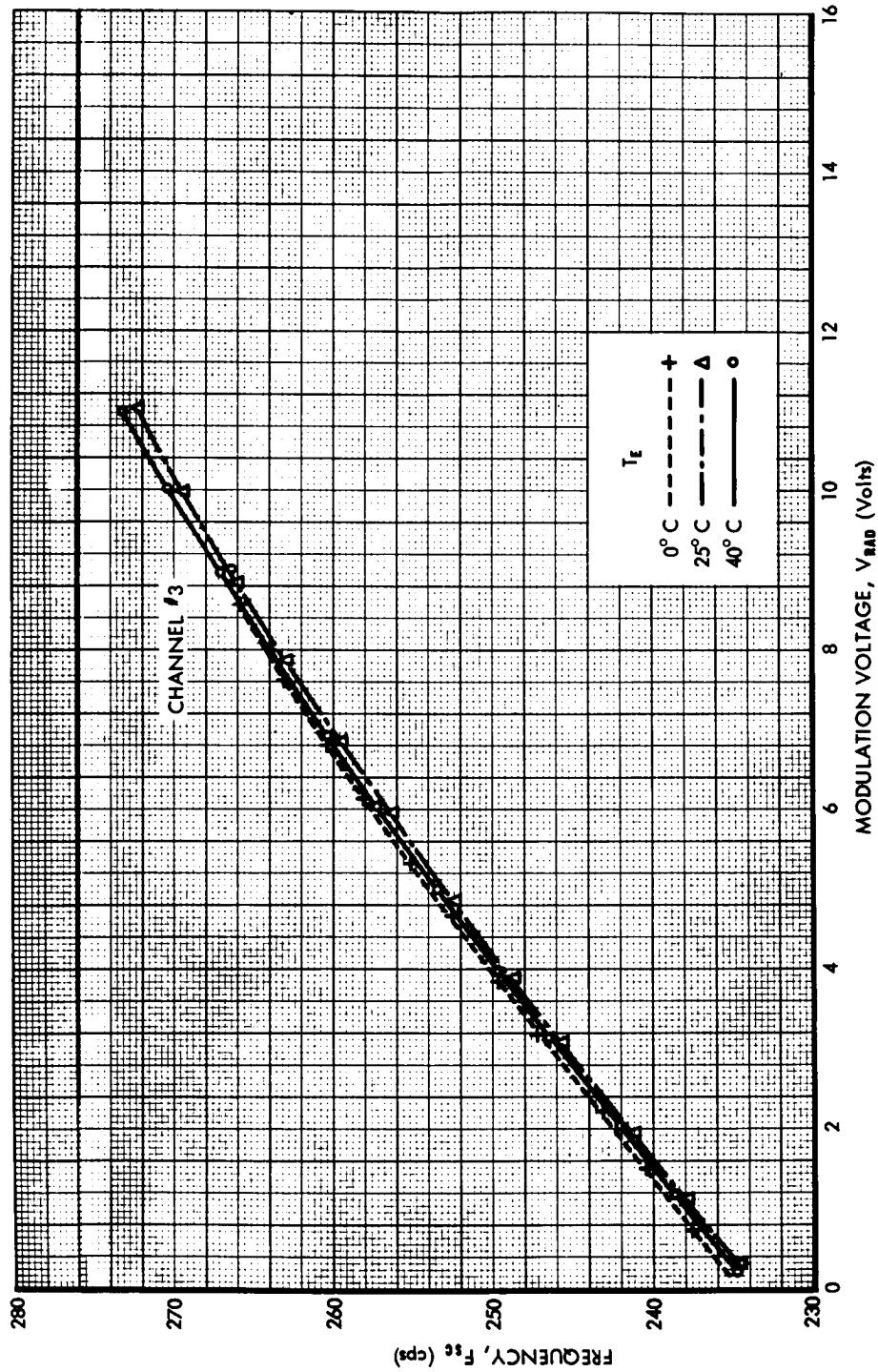


Figure 13—The response of the voltage controlled oscillator for channel 3 shown as a parametric function of the electronics temperature,  $T_e$ .

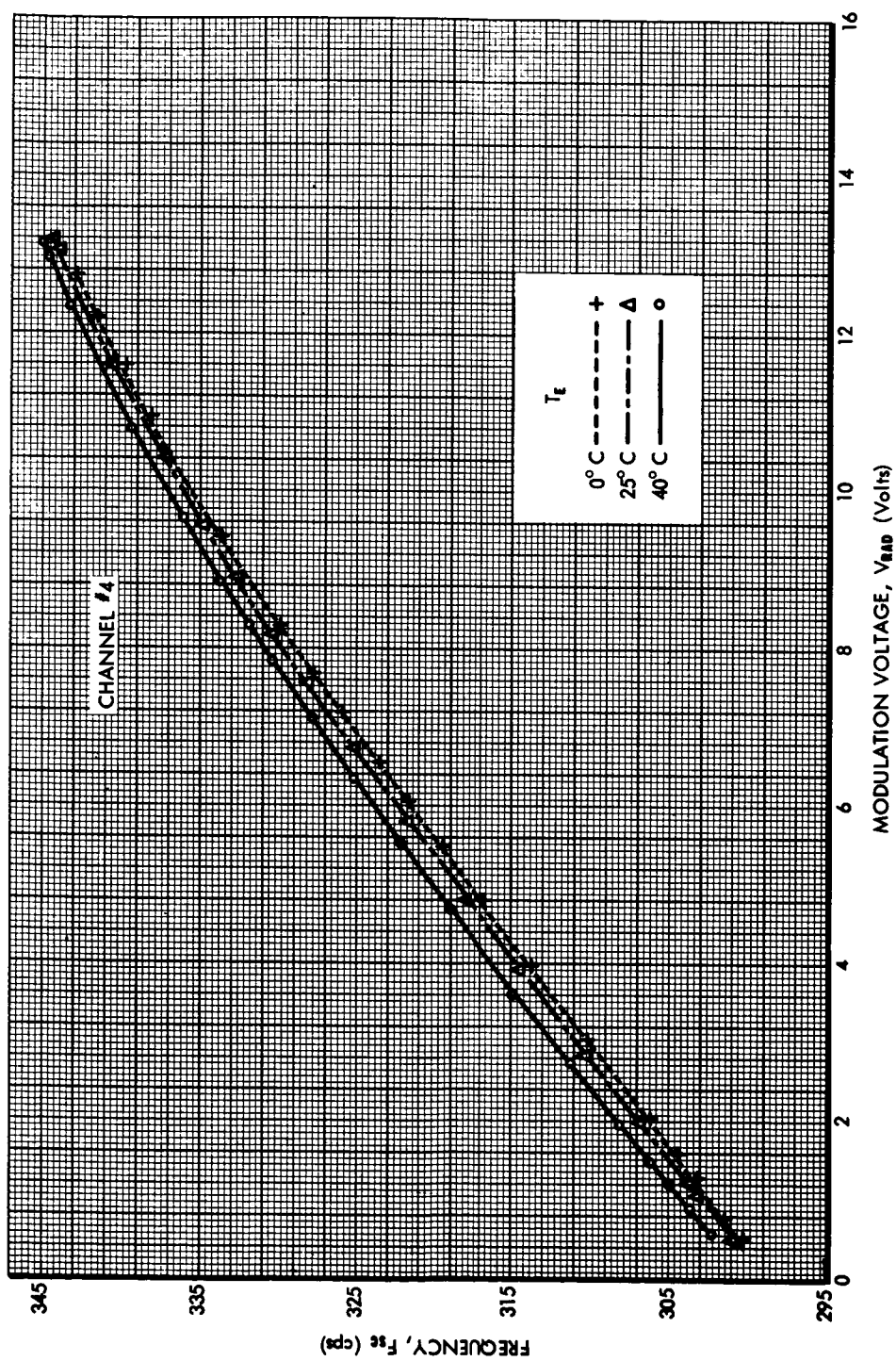


Figure 14—The response of the voltage controlled oscillator for channel 4 shown as a parametric function of the electronics temperature,  $T_e$ .

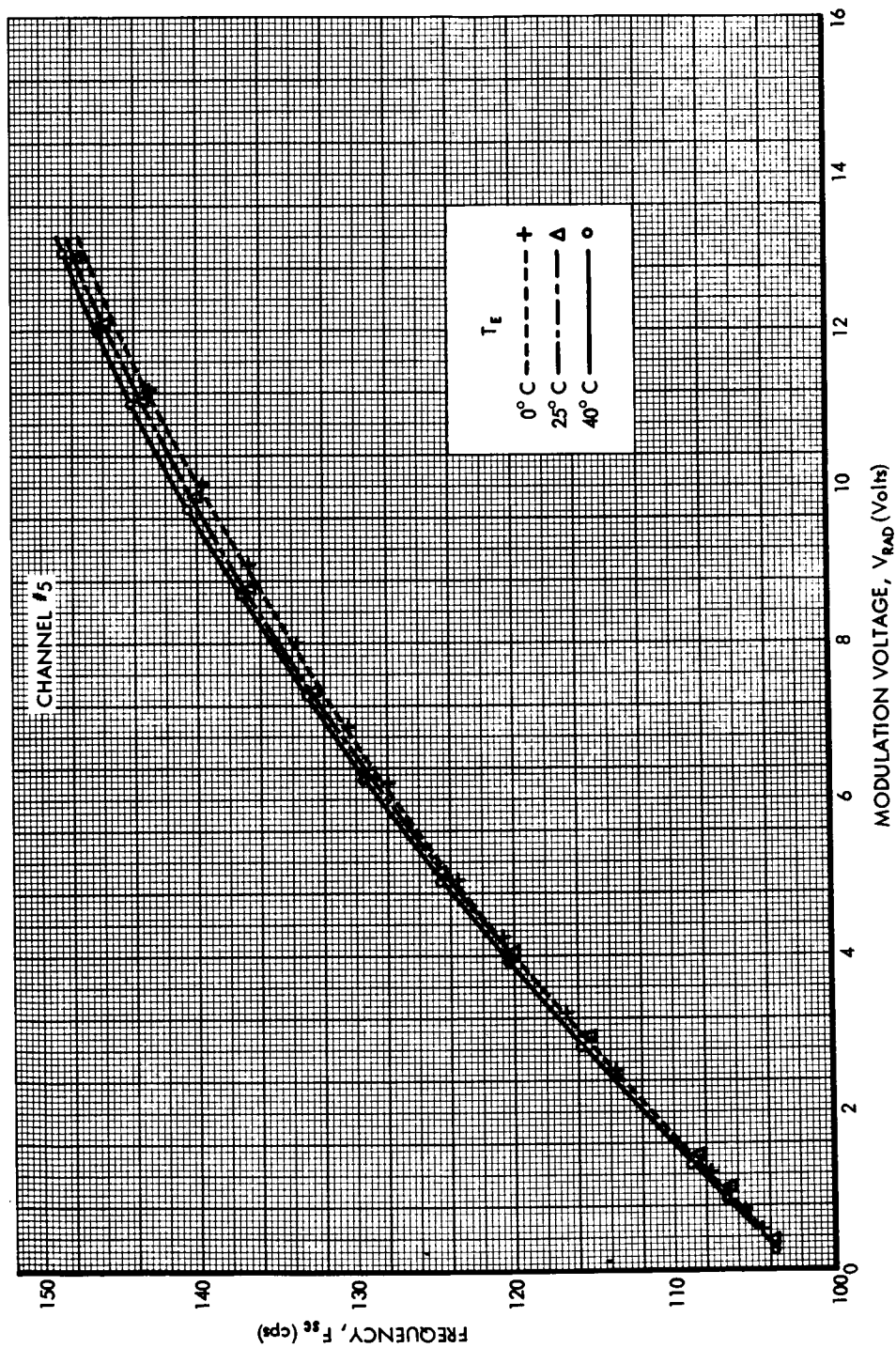


Figure 15.—The response of the voltage controlled oscillator for channel 5 shown as a parametric function of the electronics temperature,  $T_e$ .

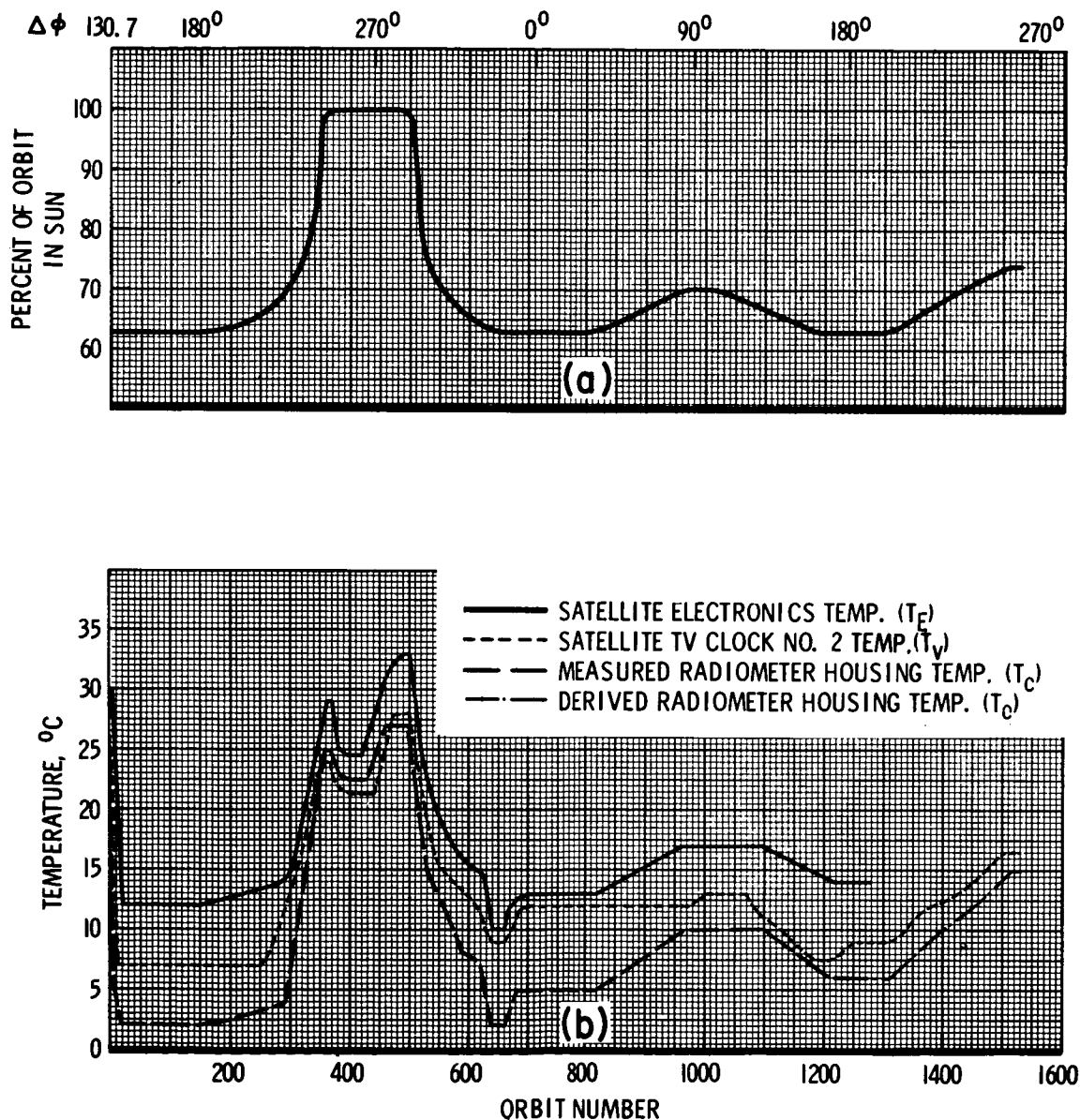


Figure 16—(a) Percent of the orbital period which the satellite spends in sunlight versus orbit number. Also shown on the upper abscissa is  $\Delta\phi$ , the right ascension of the sun minus the right ascension of the orbital ascending node. (b) Radiometer electronics temperature ( $T_E$ ), television clock number 2 temperature ( $T_V$ ), and measured and derived radiometer housing temperatures ( $T_C$ ) versus orbit number. Telemetry of the "housekeeping information" for the radiometer ceased at orbit 1276, after which  $T_C$  was derived from  $T_V$ .

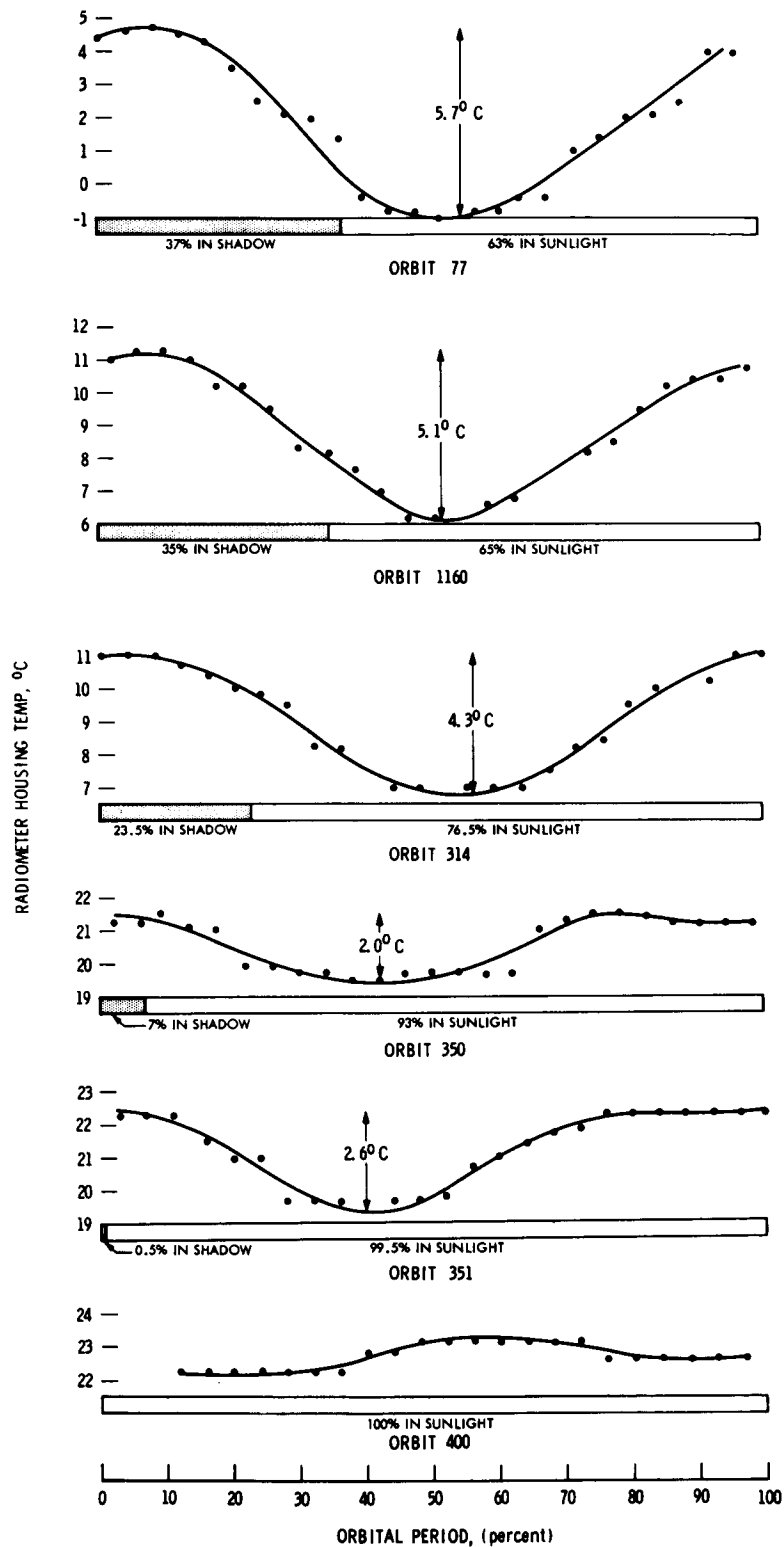


Figure 17—Selected TIROS VII orbits showing the variation of the satellite housing temperature,  $T_c$ , during an orbital period as a function of the time the satellite is in the earth's shadow or in sunlight.



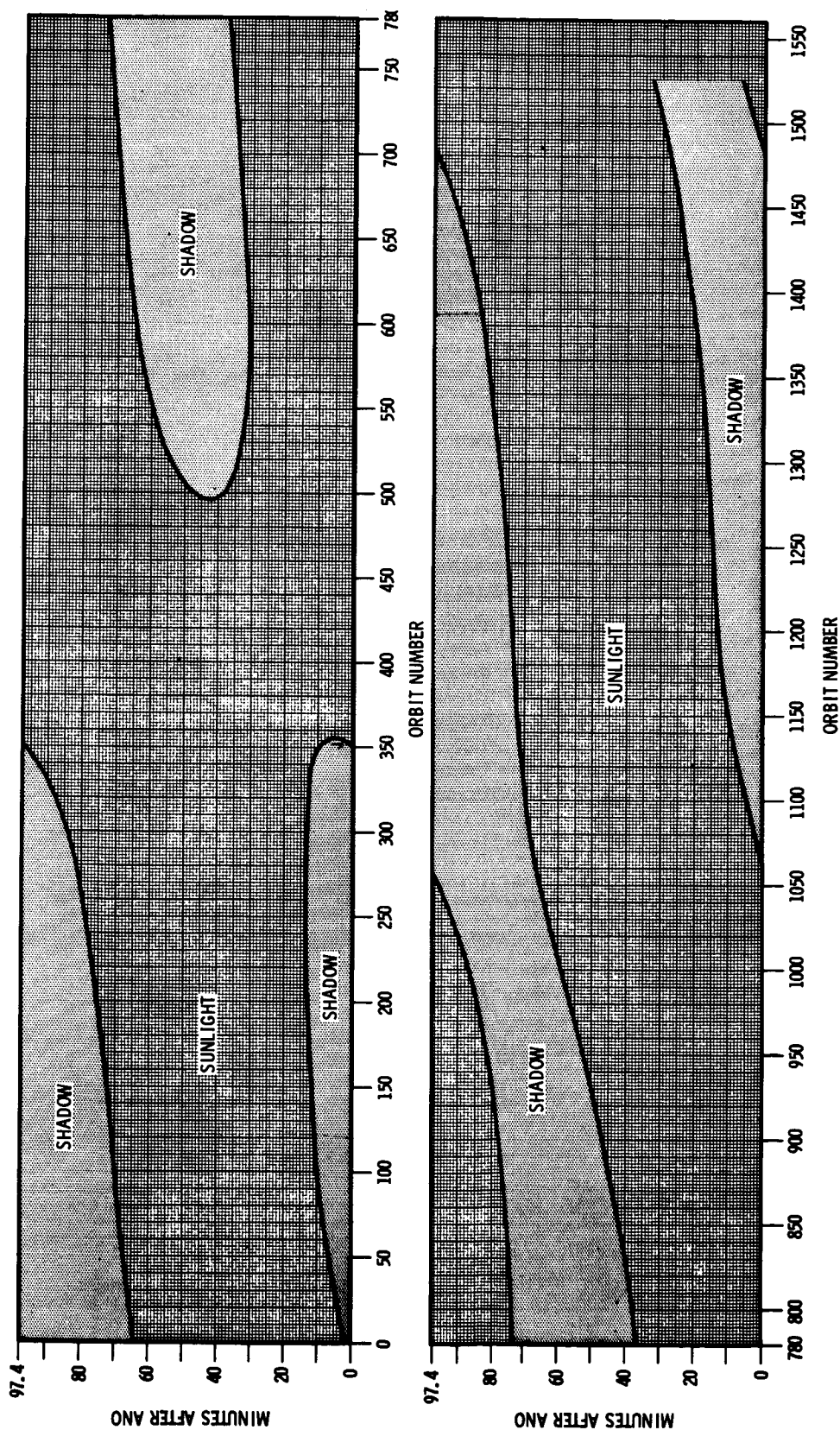


Figure 18—Portions of the 97.4-minute orbital period when the satellite is in sunlight and in the earth's shadow, expressed in minutes after the ascending node, versus orbit number.



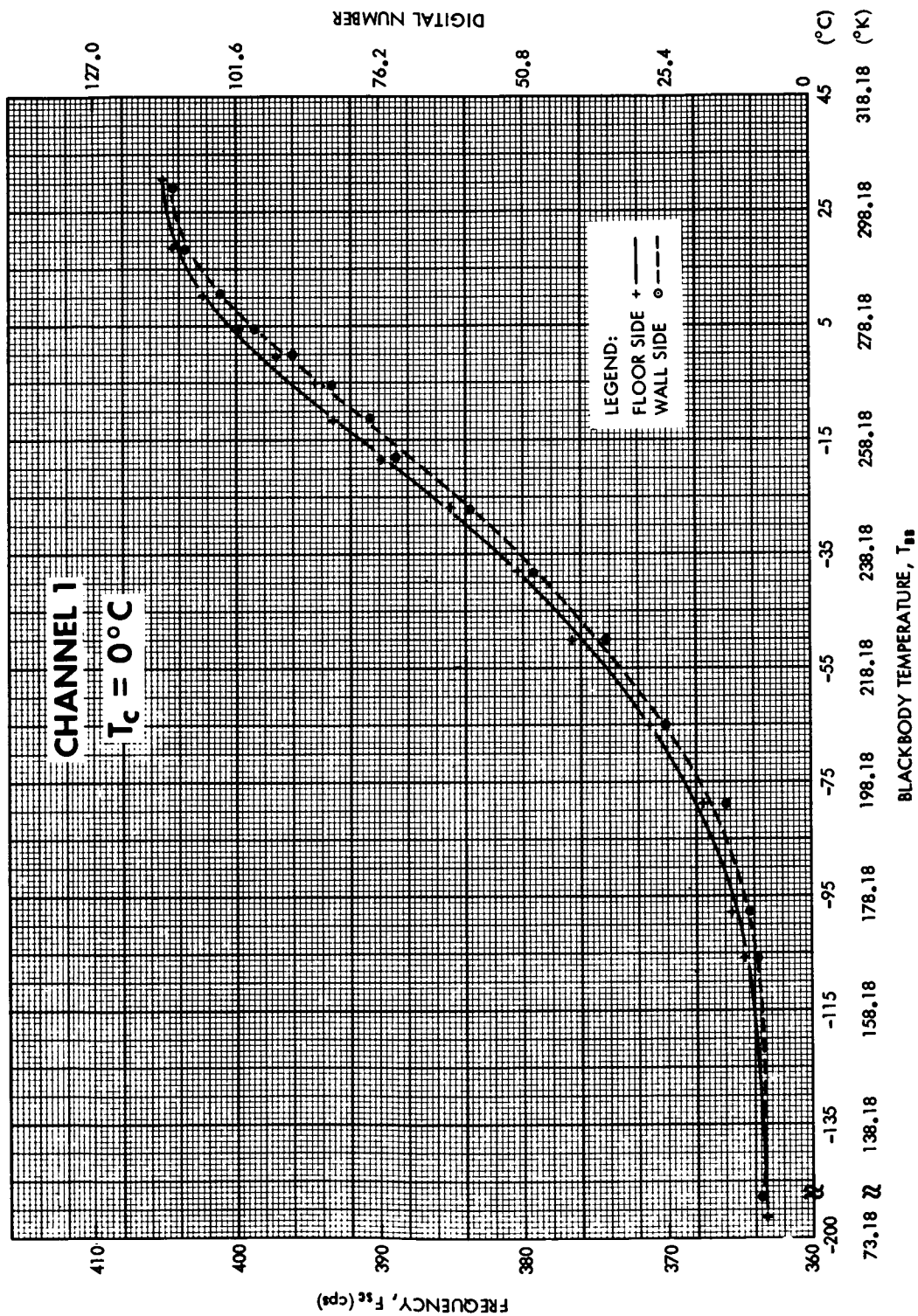


Figure 19—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 1. ( $T_c = 0^\circ\text{C}$ )

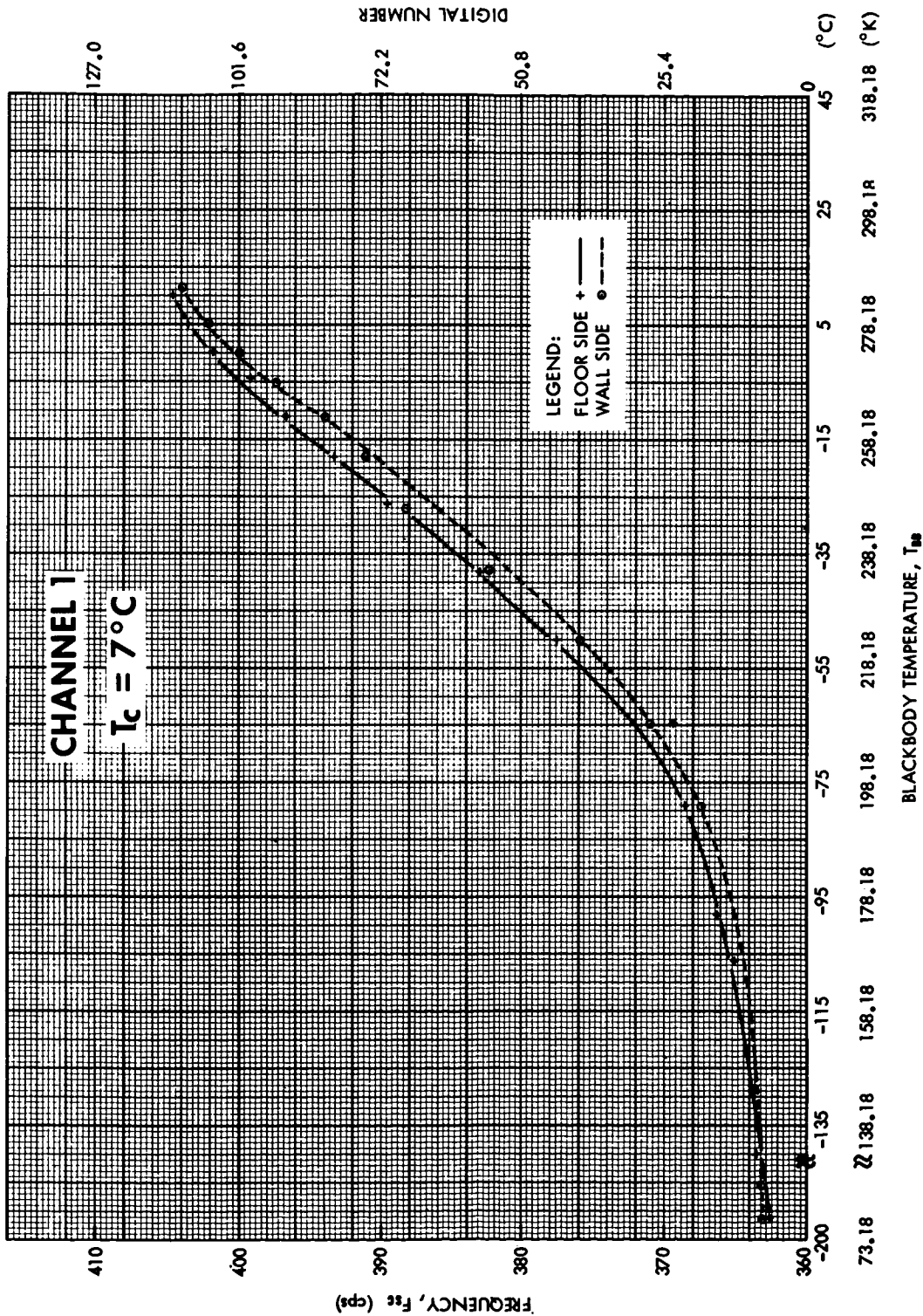


Figure 20—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 1. ( $T_c = 7^\circ\text{C}$ )

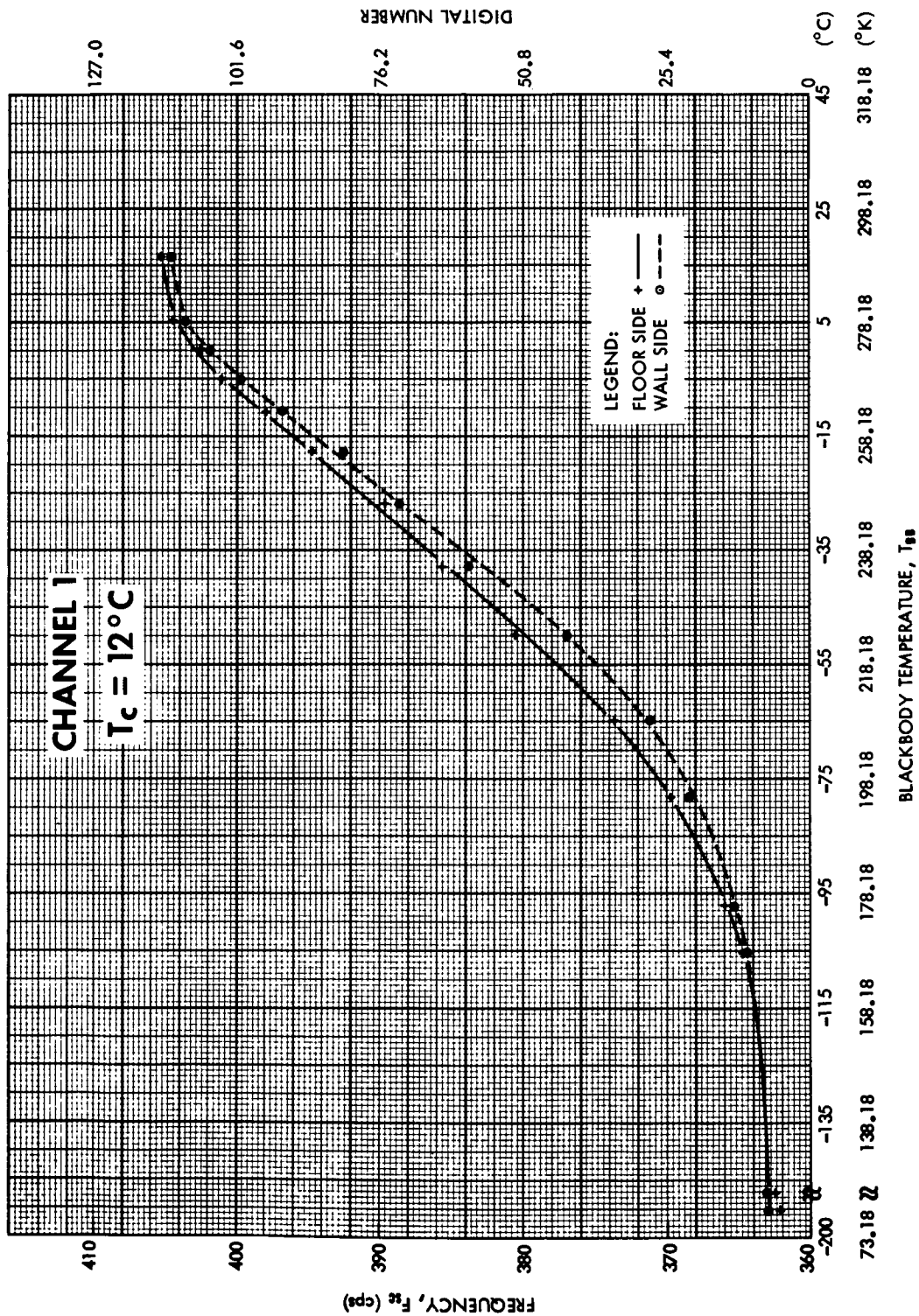


Figure 21—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 1. ( $T_c = 12^\circ\text{C}$ )

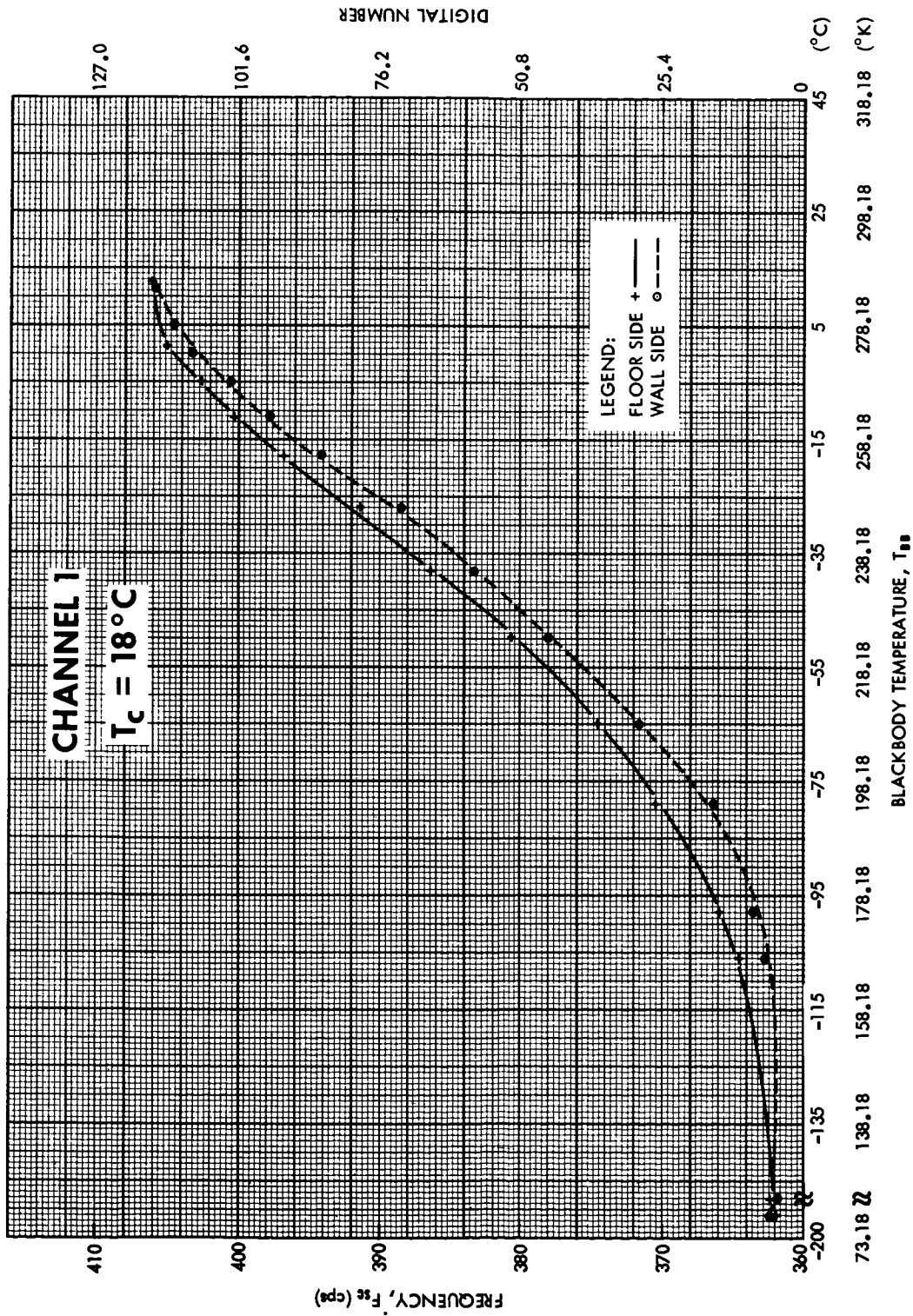


Figure 22—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 1. ( $T_c = 18^\circ\text{C}$ )

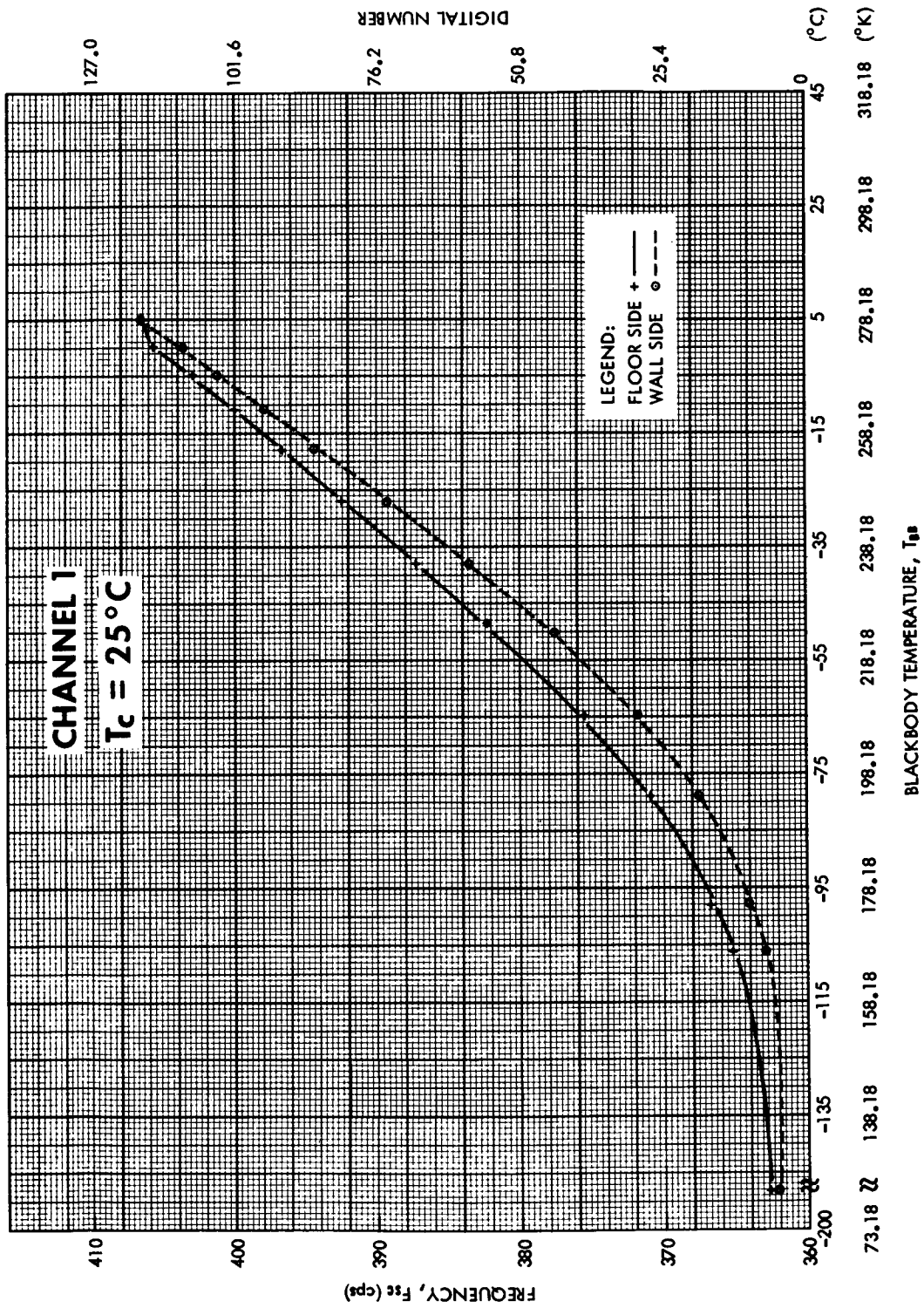


Figure 23—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 1. ( $T_c = 25^\circ\text{C}$ )

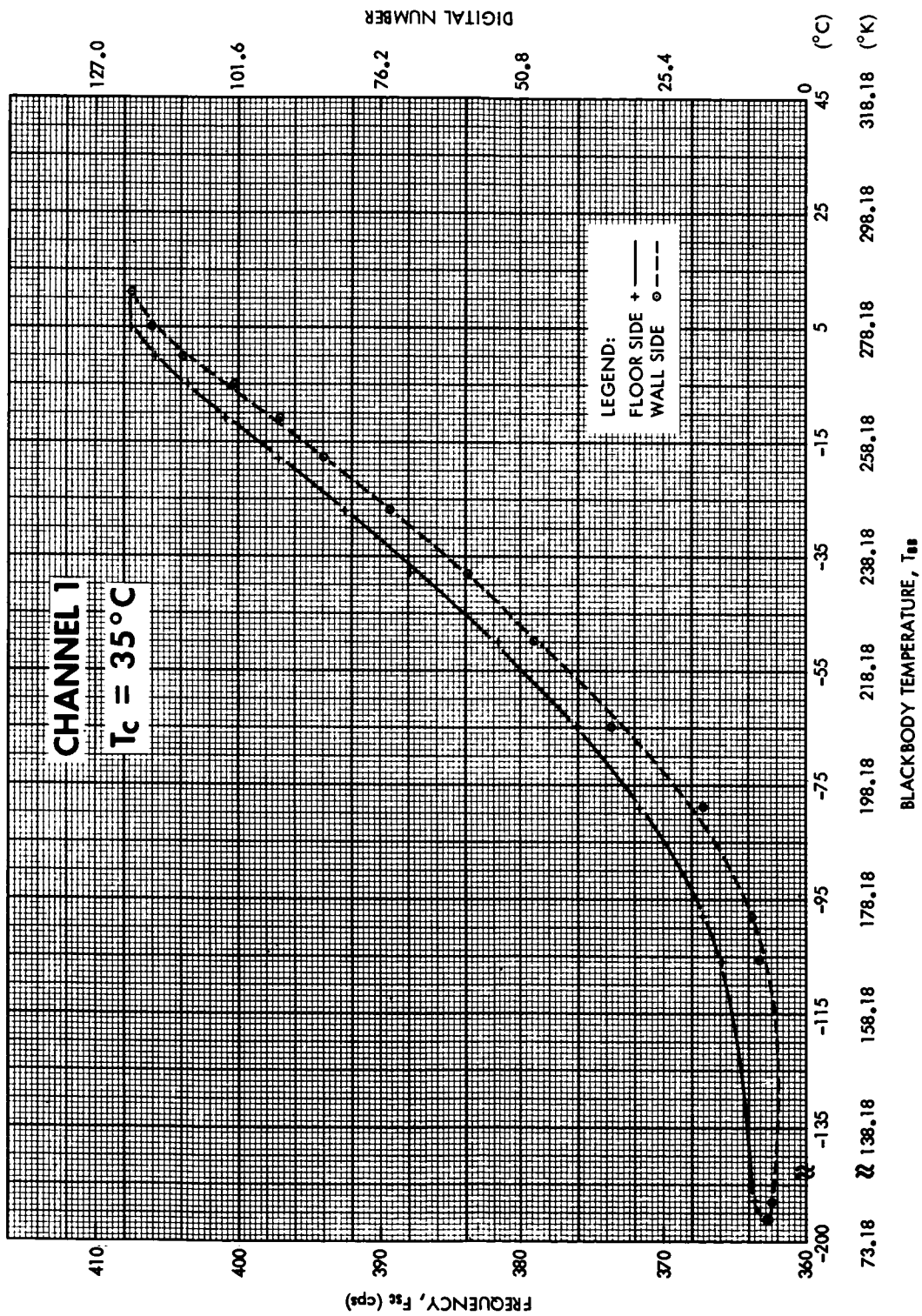


Figure 24—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 1. ( $T_c = 35^\circ\text{C}$ )



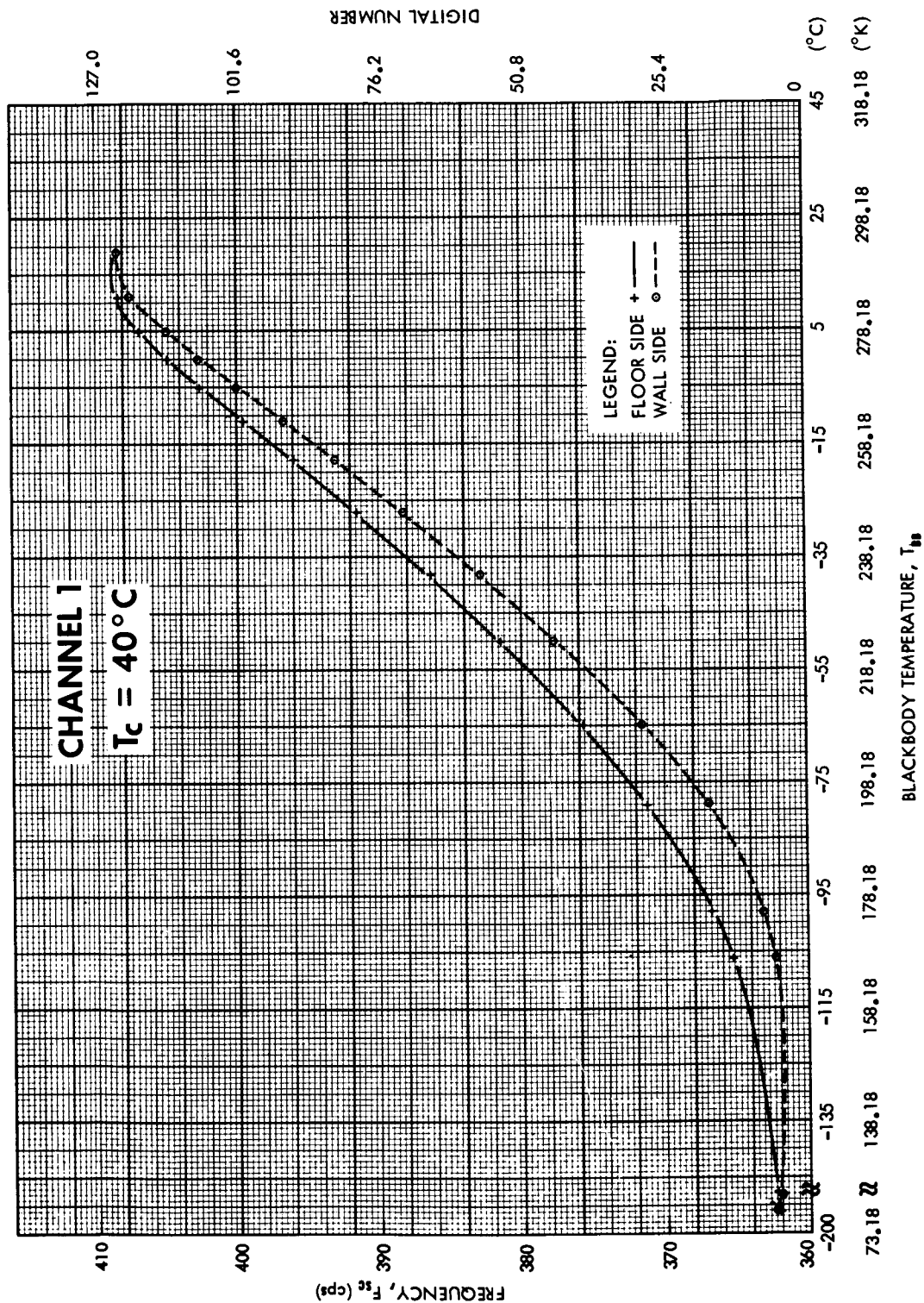


Figure 25—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 1. ( $T_c = 40^\circ\text{C}$ )

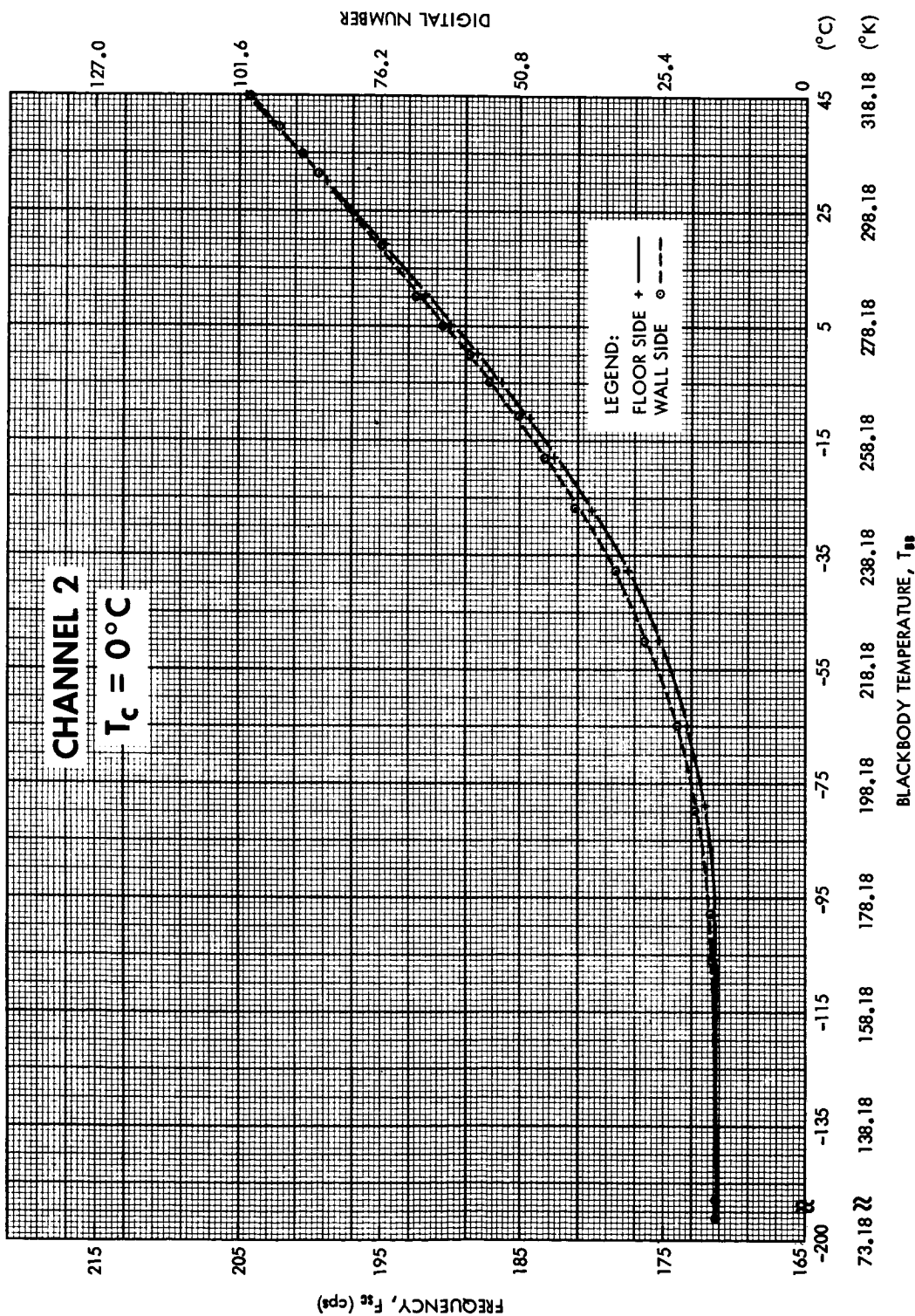


Figure 20—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 2. ( $T_c = 0^\circ\text{C}$ )



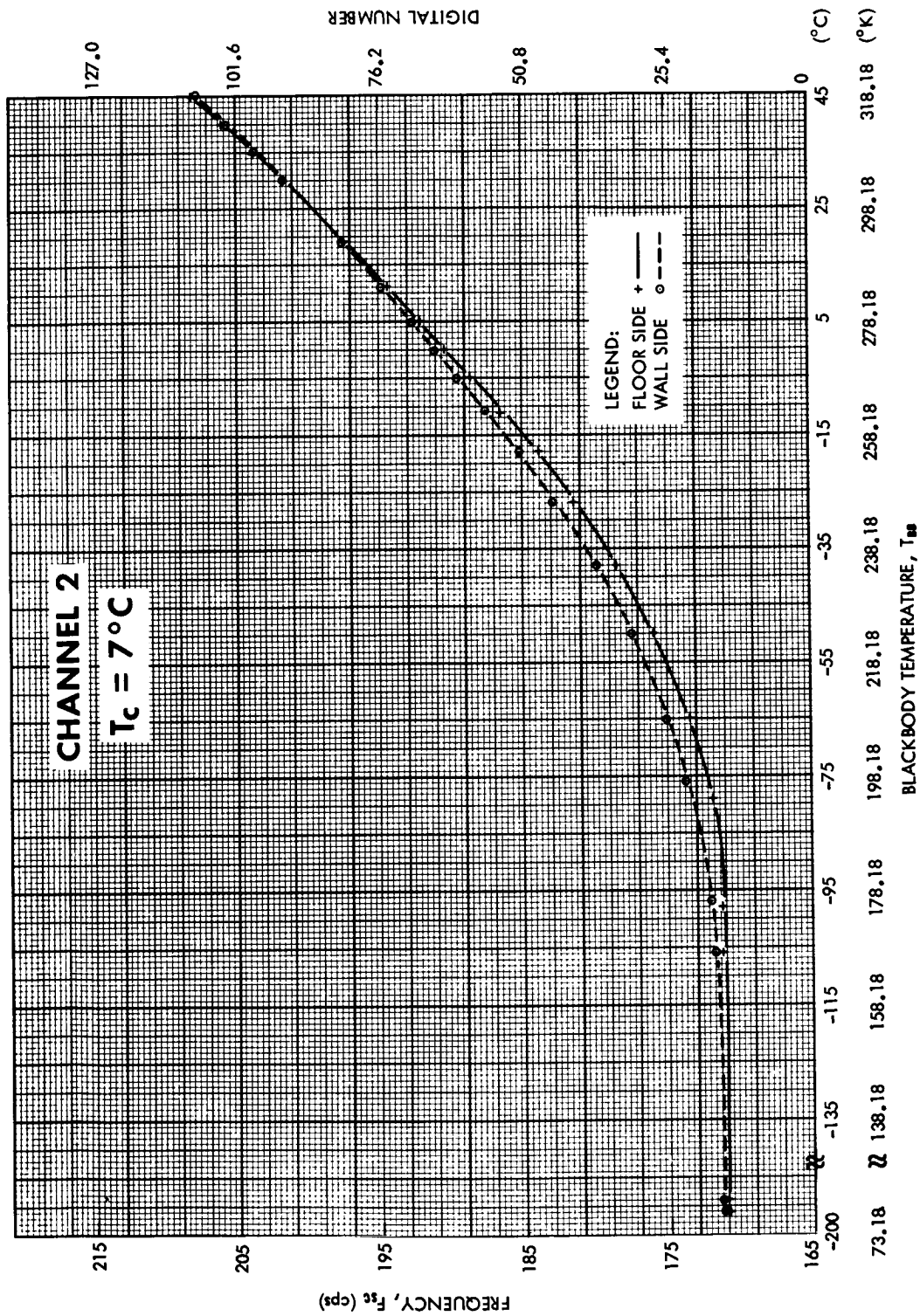


Figure 27—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 2. ( $T_c = 7^\circ\text{C}$ )

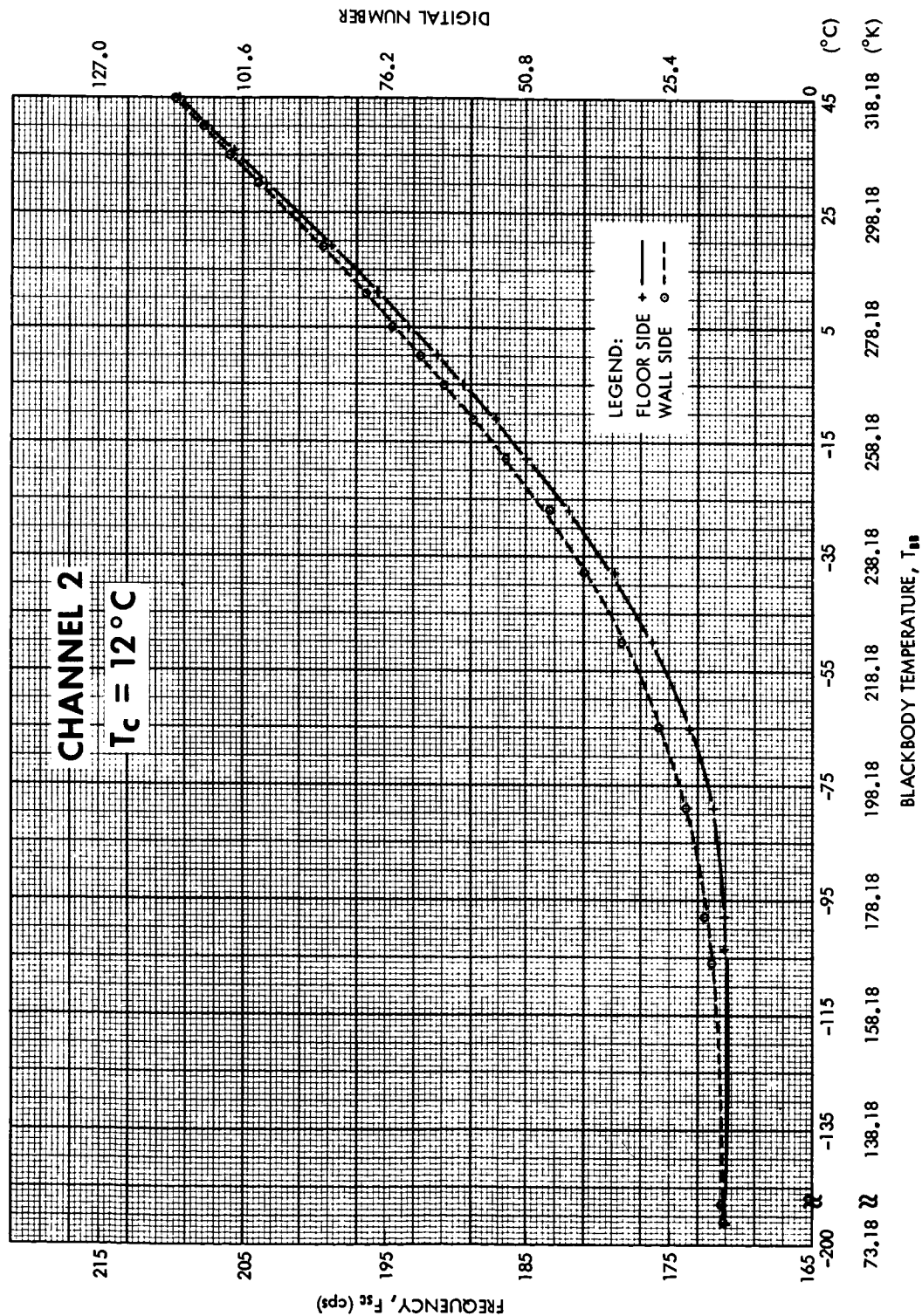


Figure 28—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 2. ( $T_c = 12^\circ\text{C}$ )

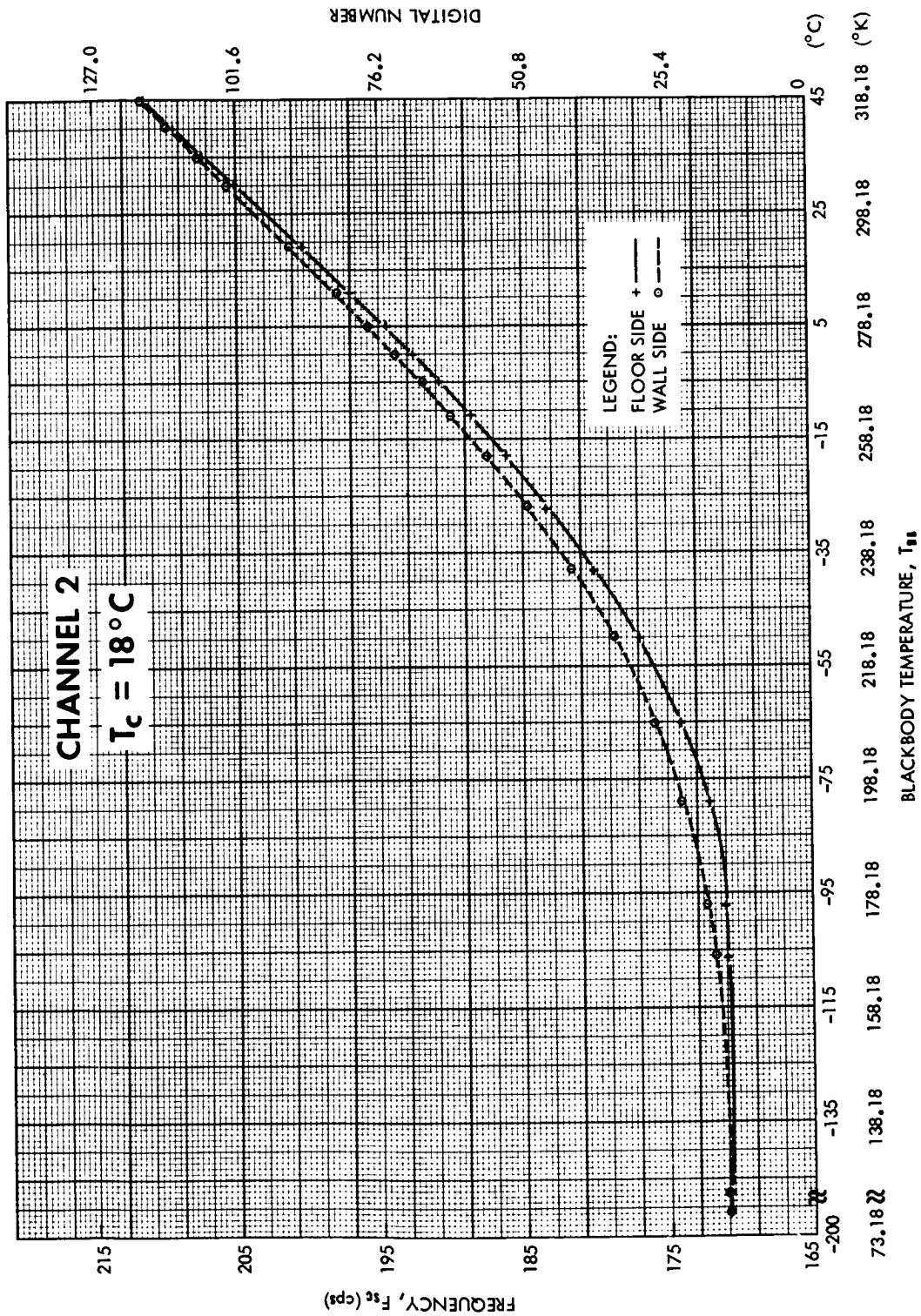


Figure 29—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 2. ( $T_c = 18^\circ\text{C}$ )

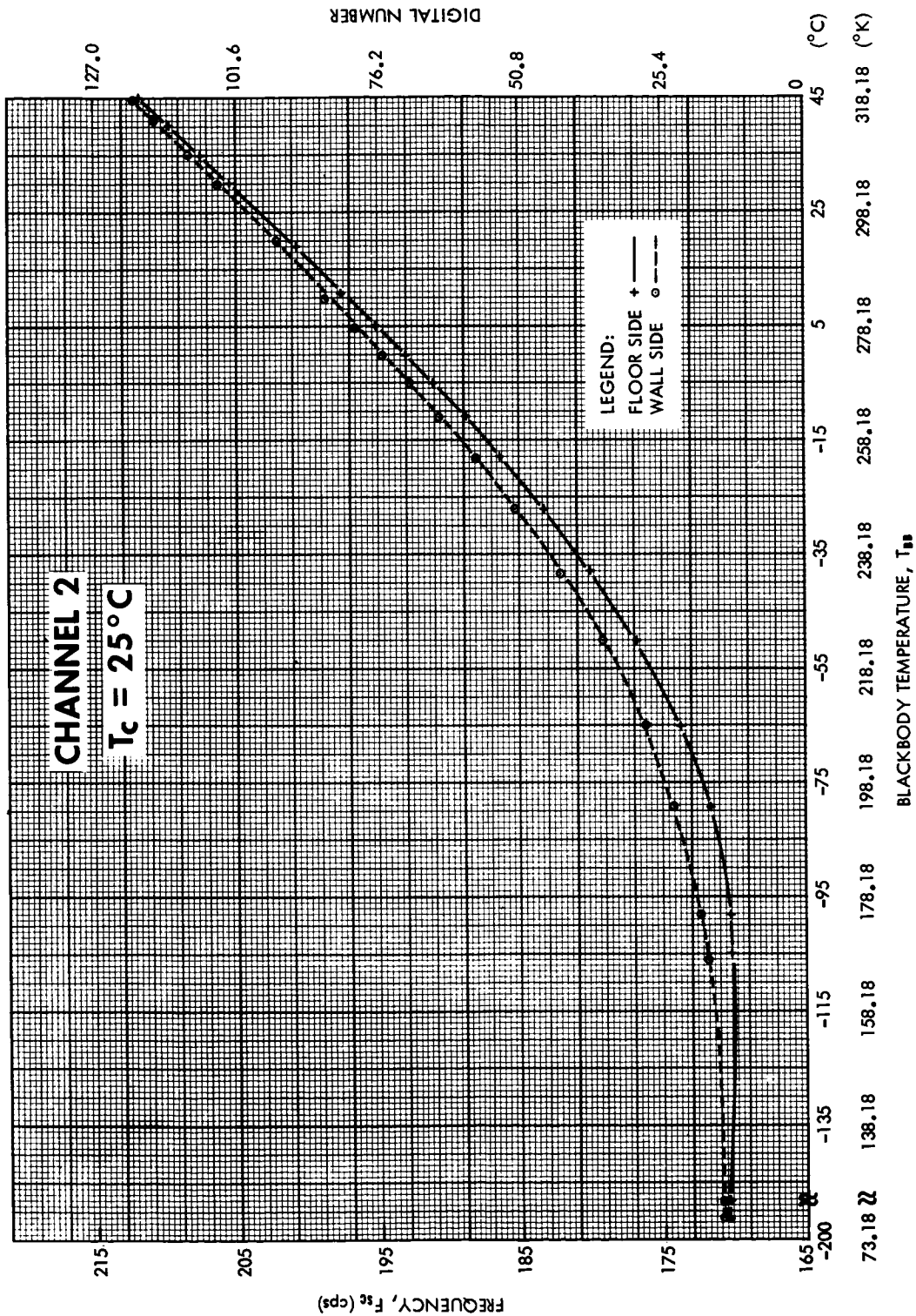


Figure 30—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 2. ( $T_c = 25^\circ\text{C}$ )

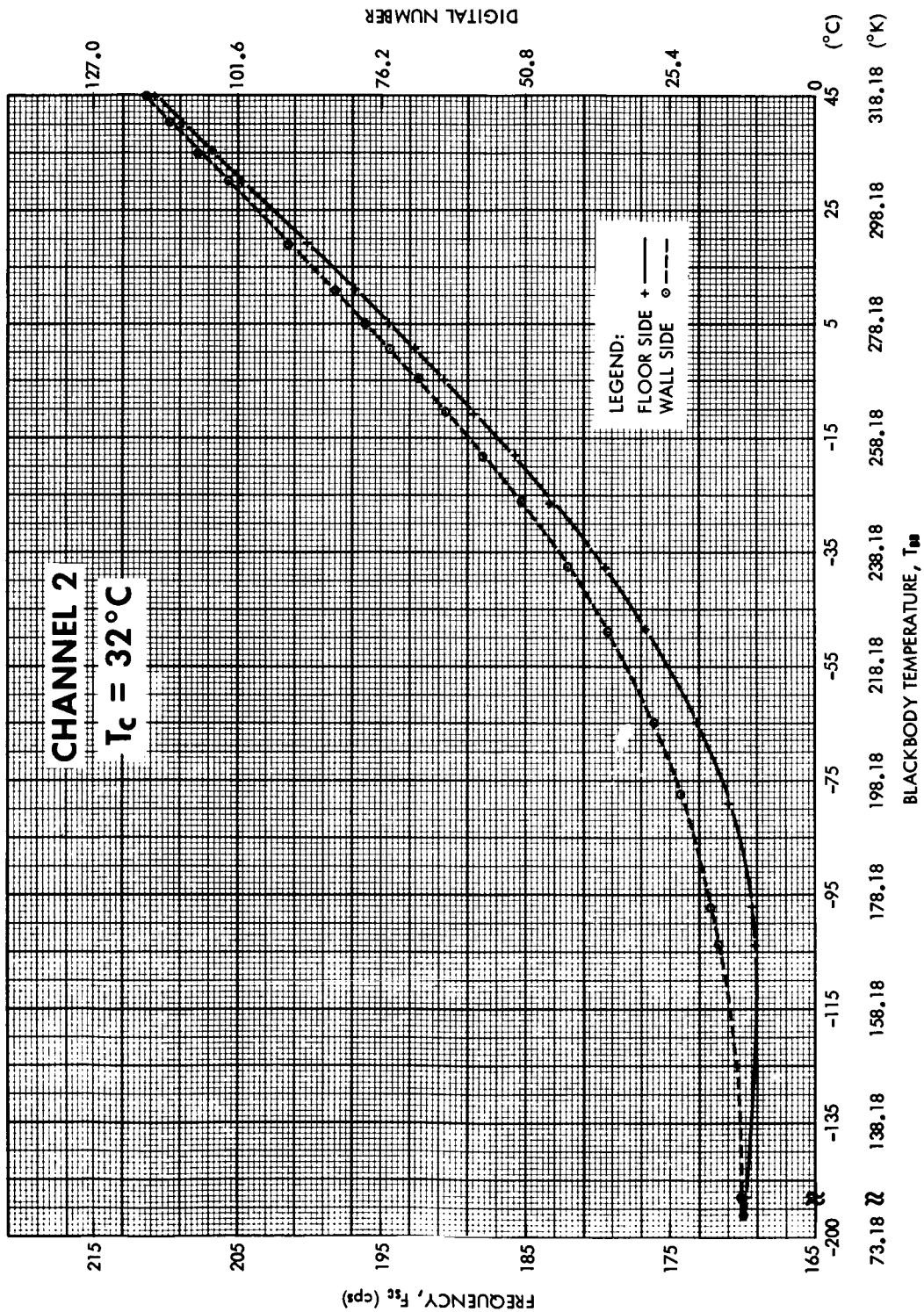


Figure 31—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 2. ( $T_c = 32^\circ\text{C}$ )

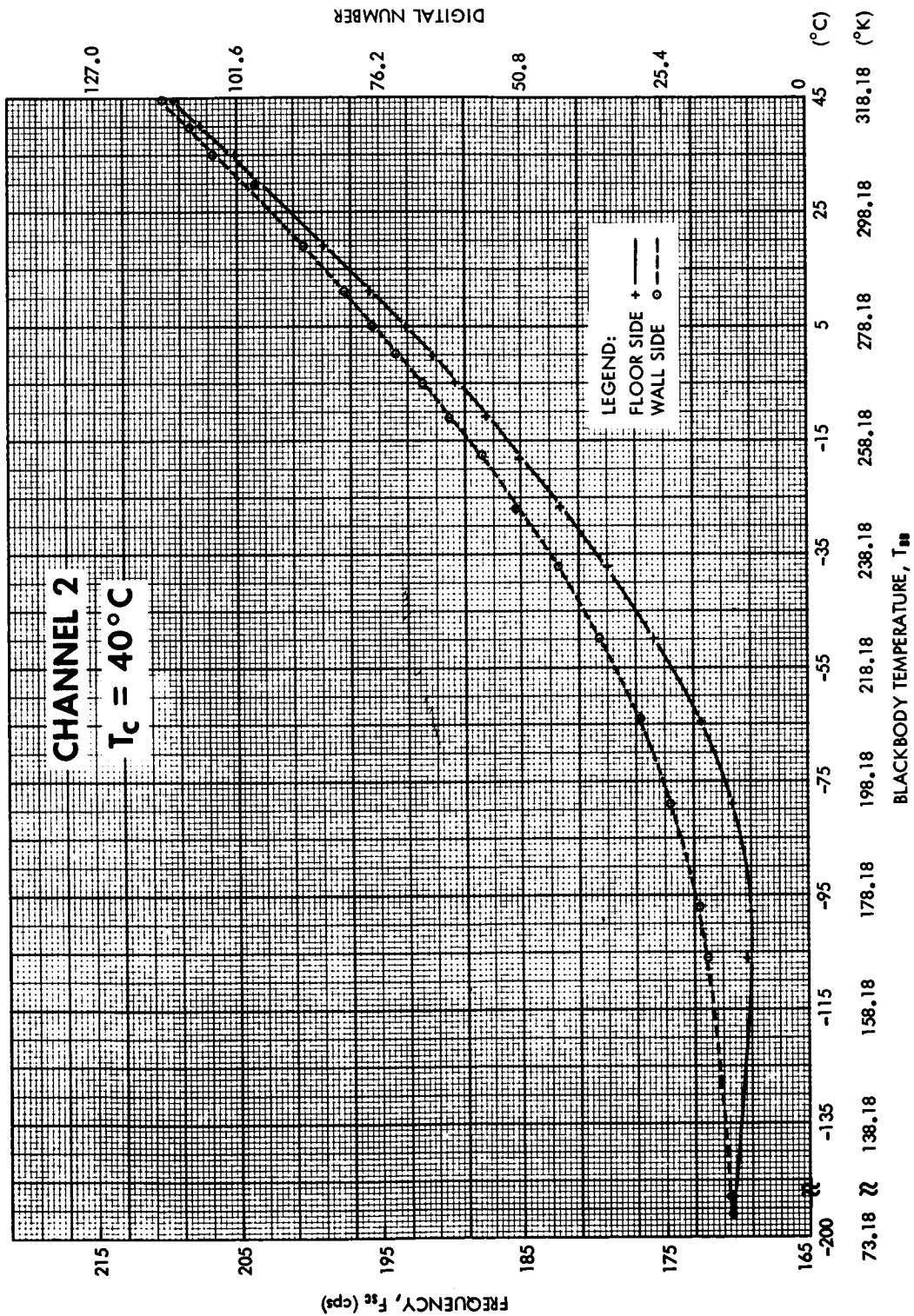


Figure 32—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 2. ( $T_c = 40^\circ\text{C}$ )



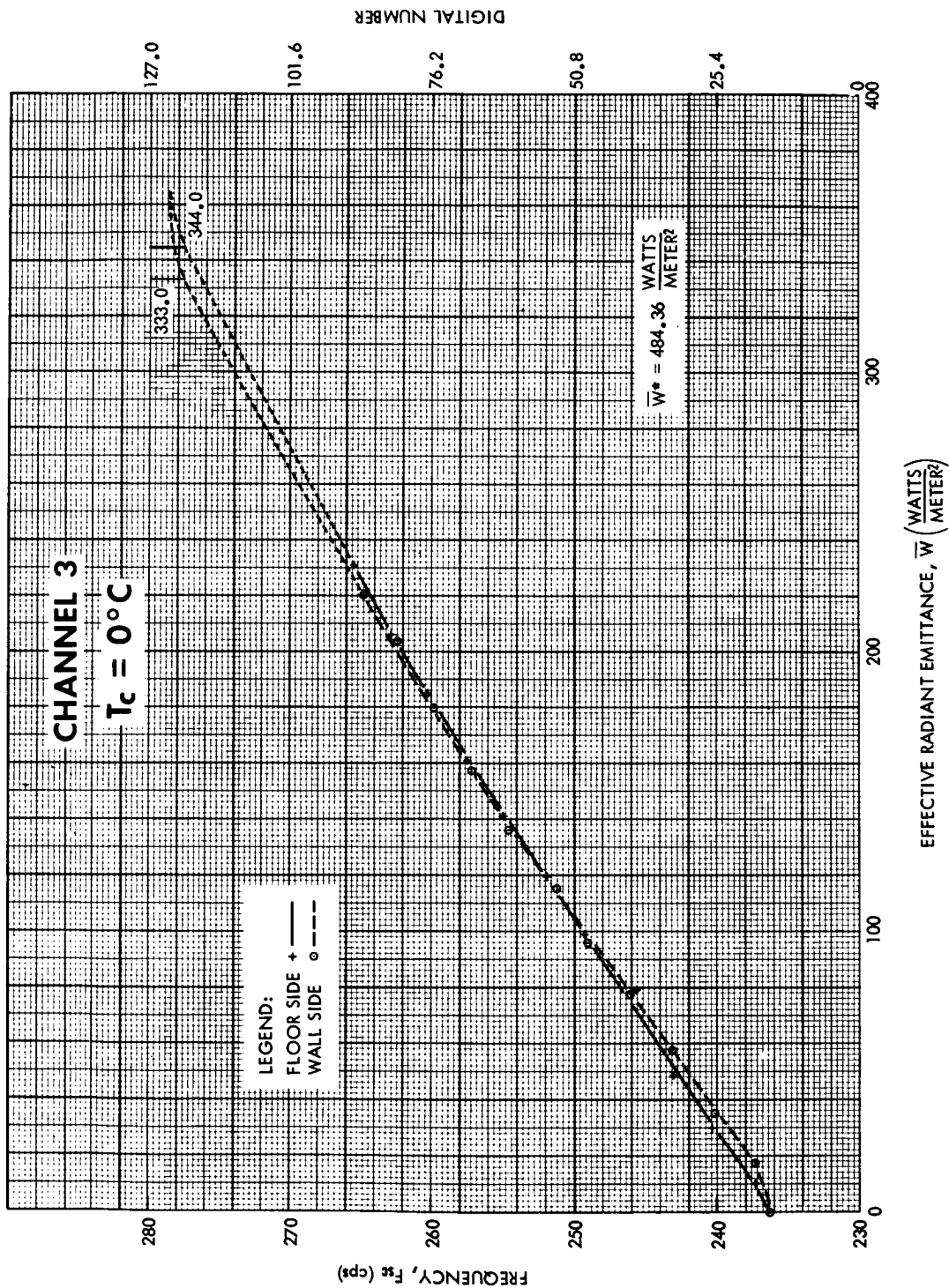


Figure 33—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 3. ( $T_c = 0^\circ\text{C}$ )

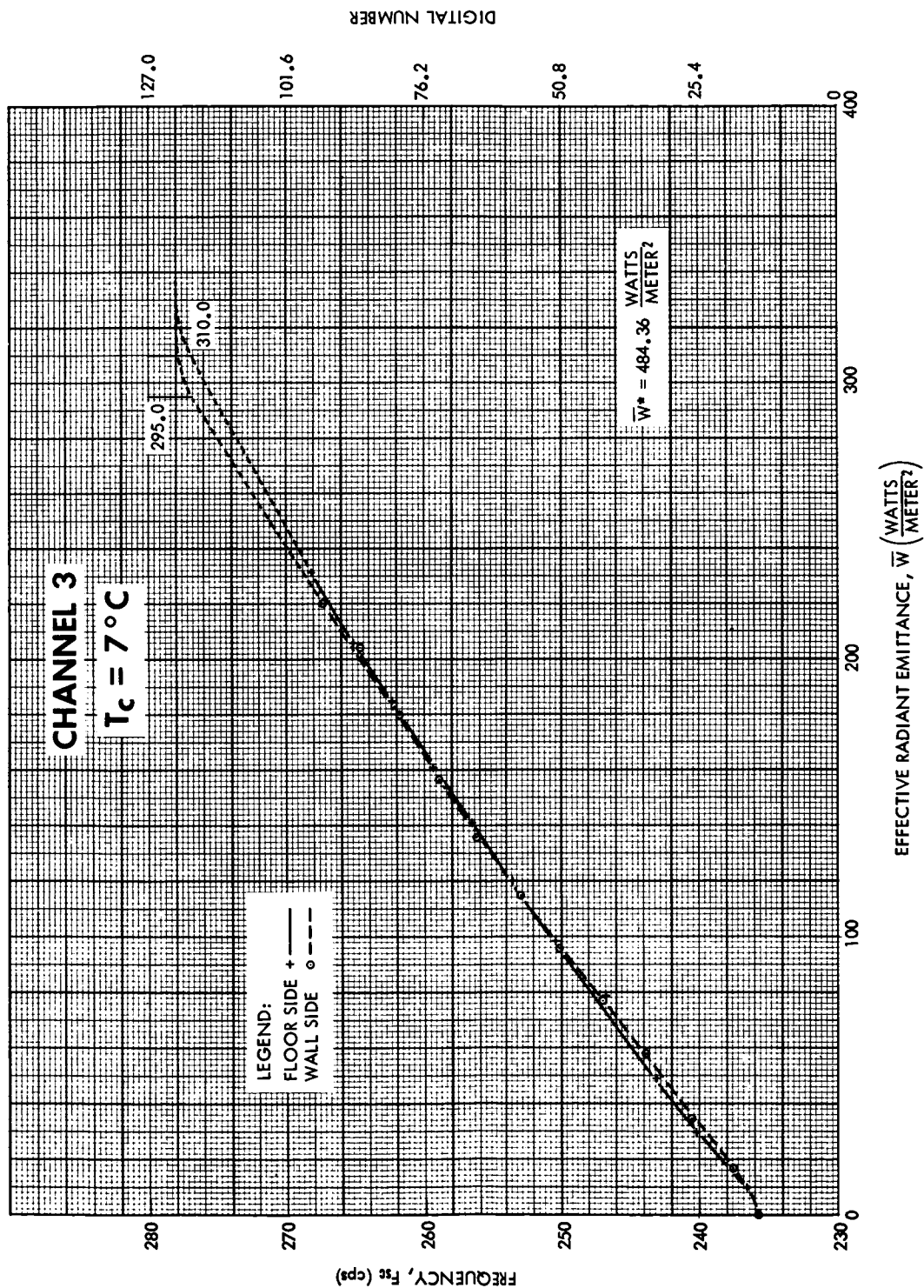


Figure 34—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 3. ( $T_c = 7^\circ\text{C}$ )



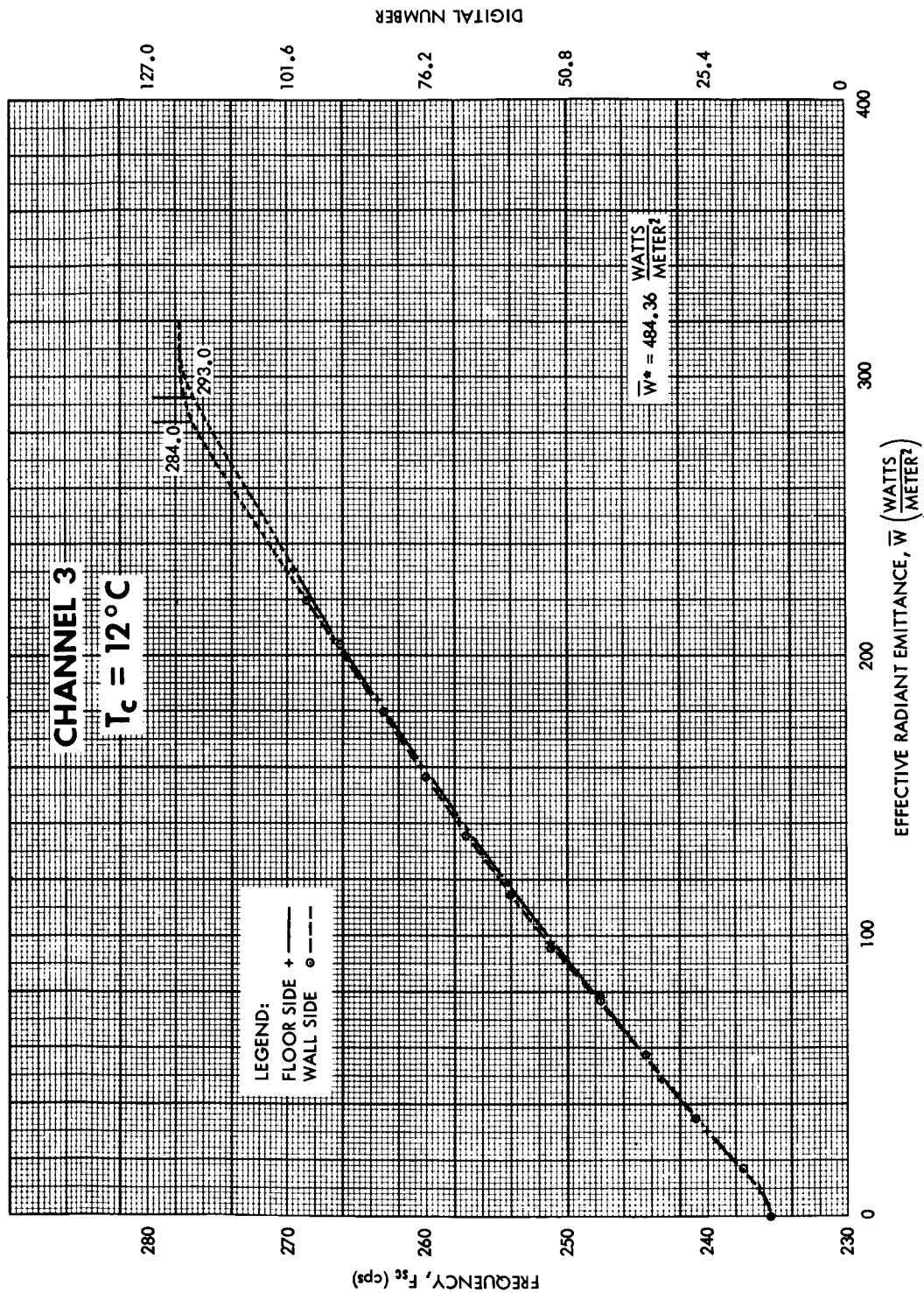


Figure 35—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 3. ( $T_c = 12^\circ\text{C}$ )

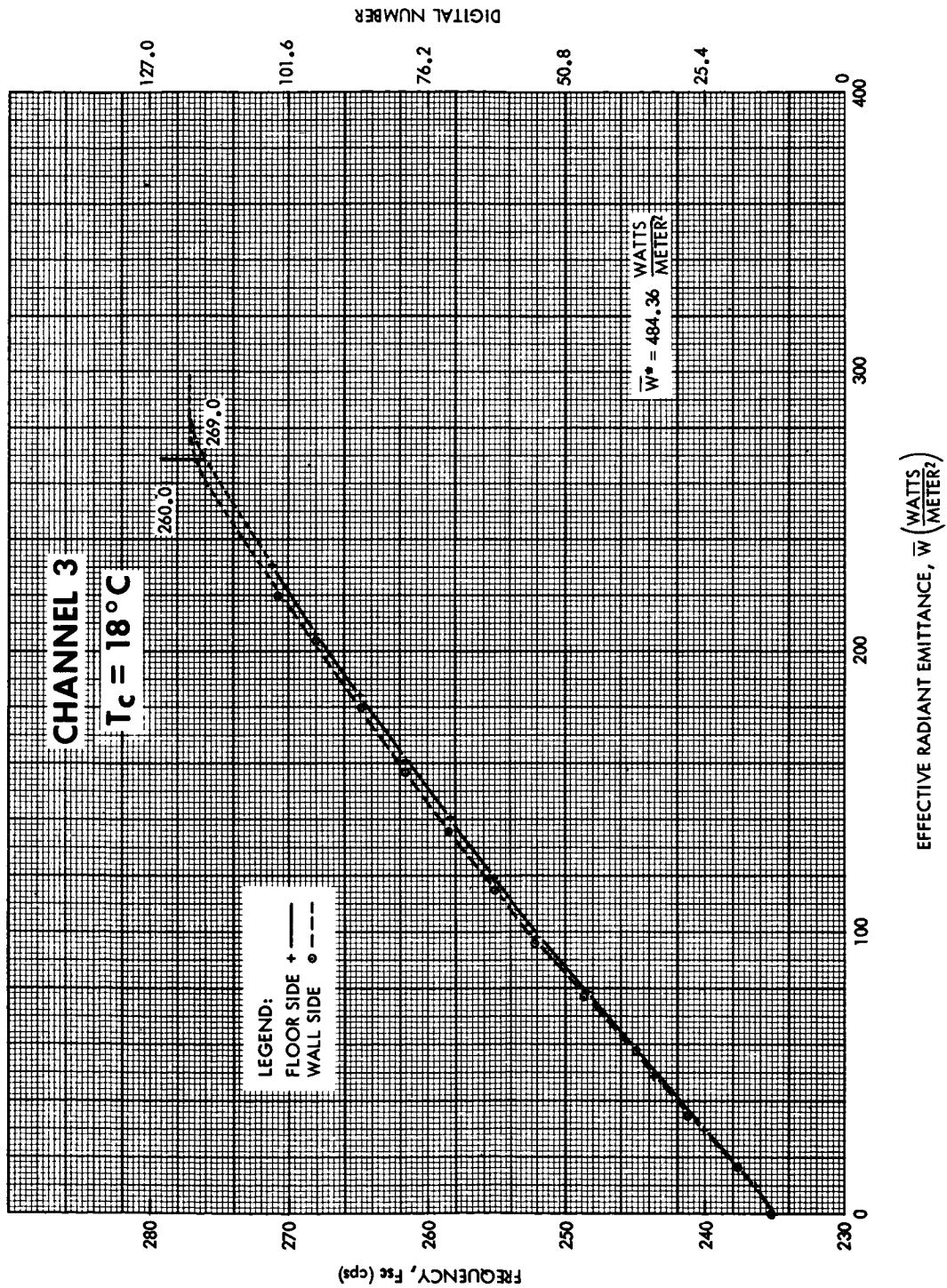


Figure 36—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 3. ( $T_c = 18^\circ\text{C}$ )

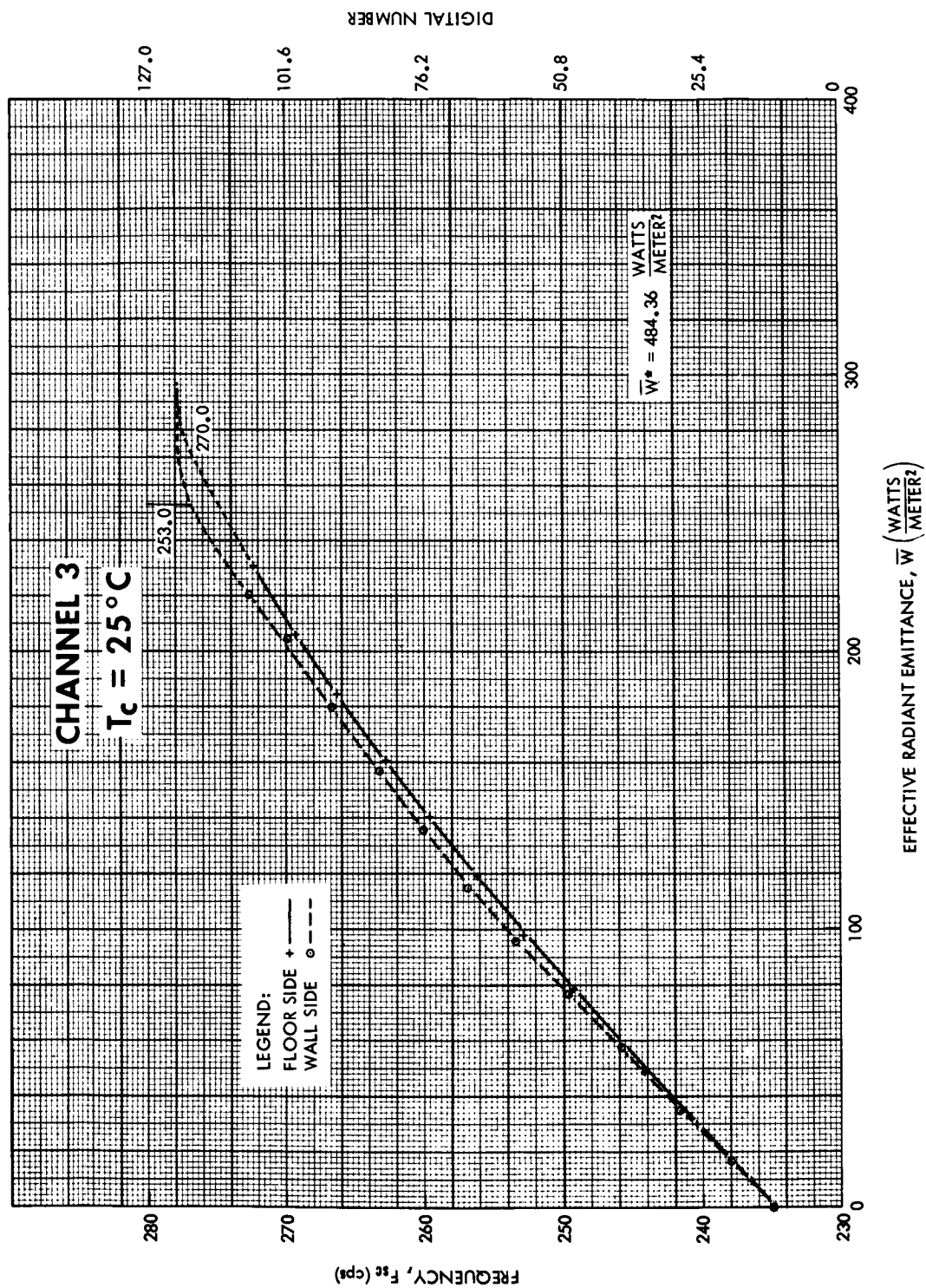


Figure 37—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 3. ( $T_c = 25^\circ\text{C}$ )

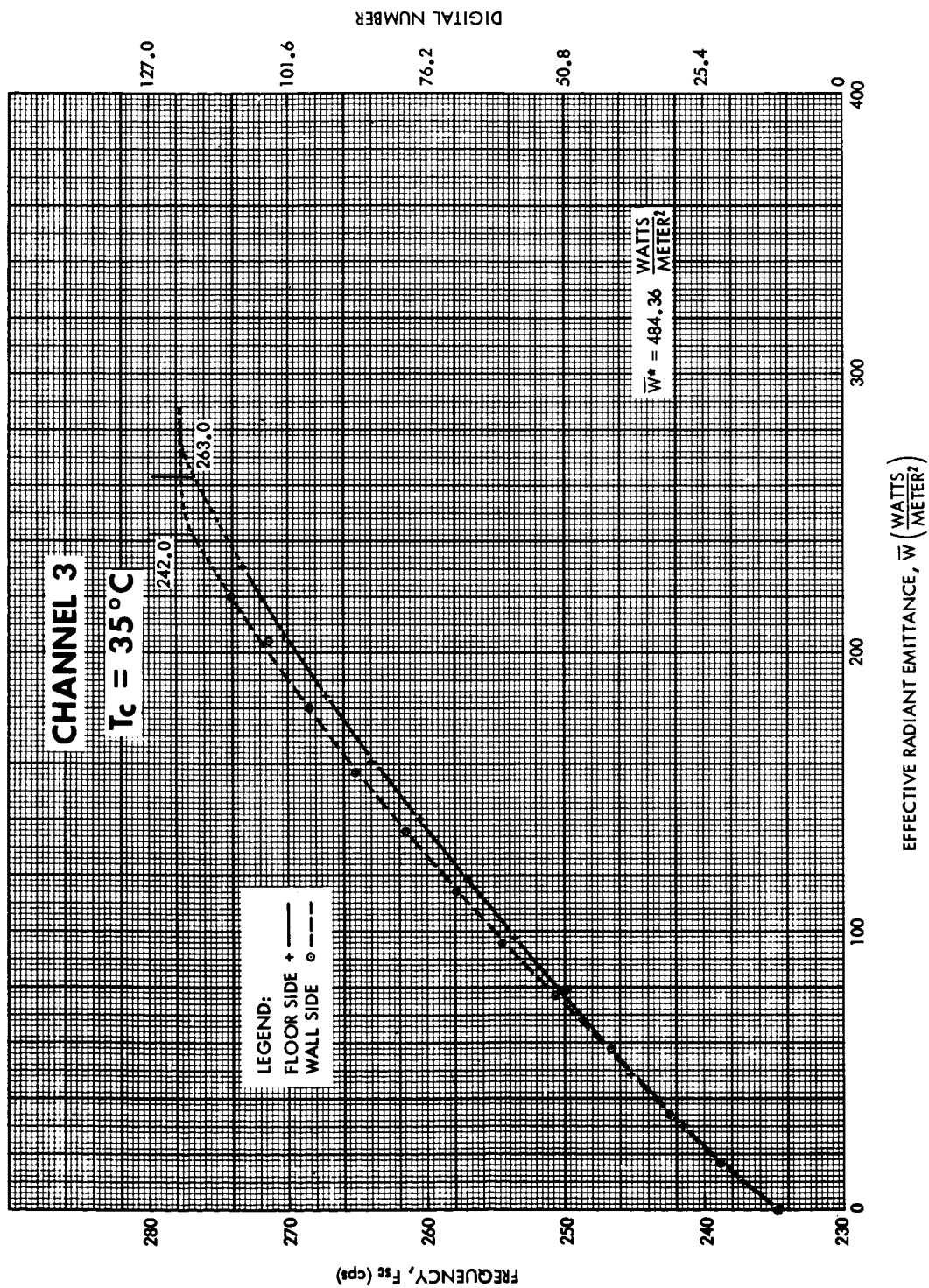


Figure 38—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 3. ( $T_c = 35^\circ\text{C}$ )

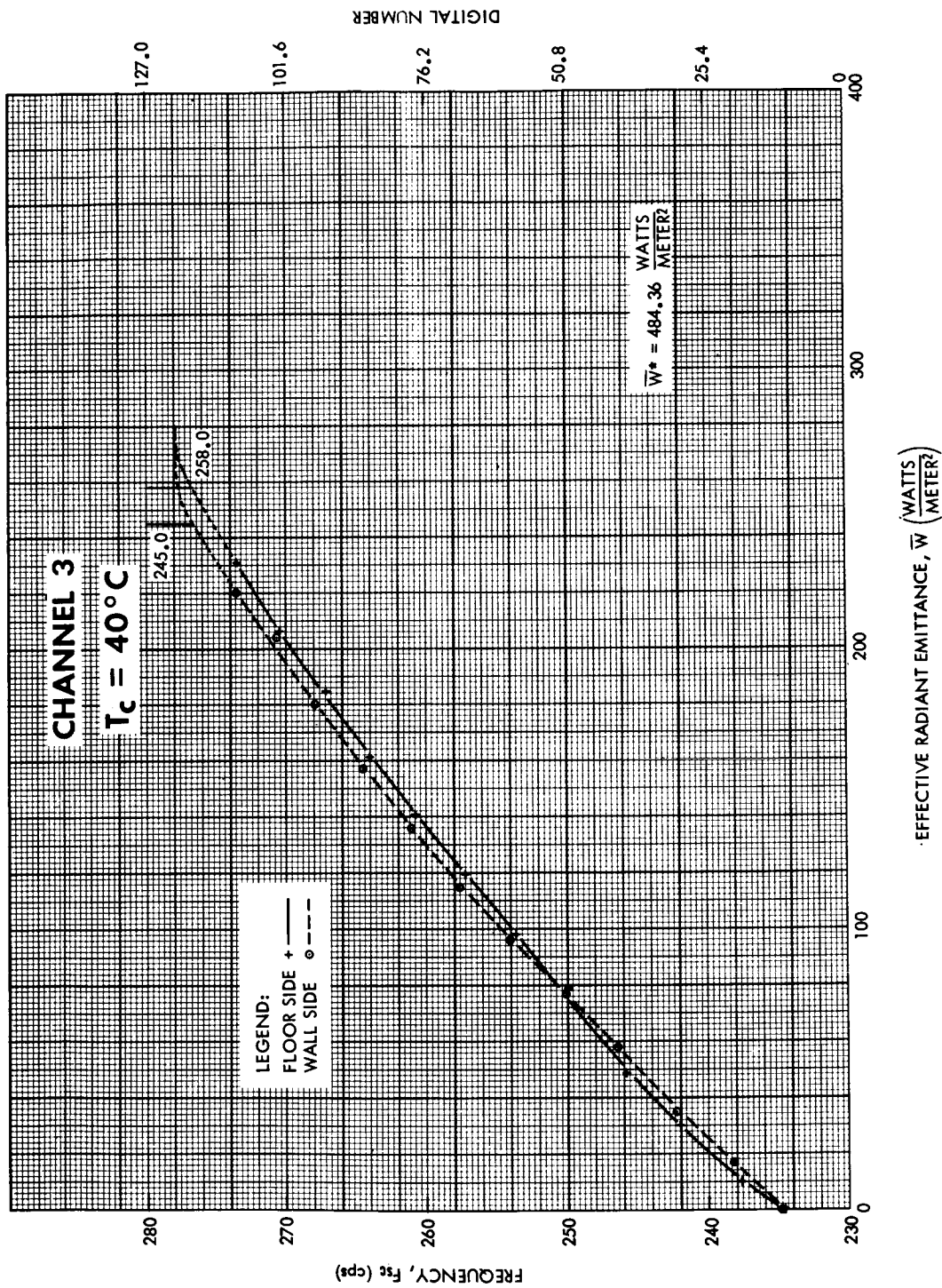


Figure 39—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 3. ( $T_c = 40^\circ\text{C}$ )

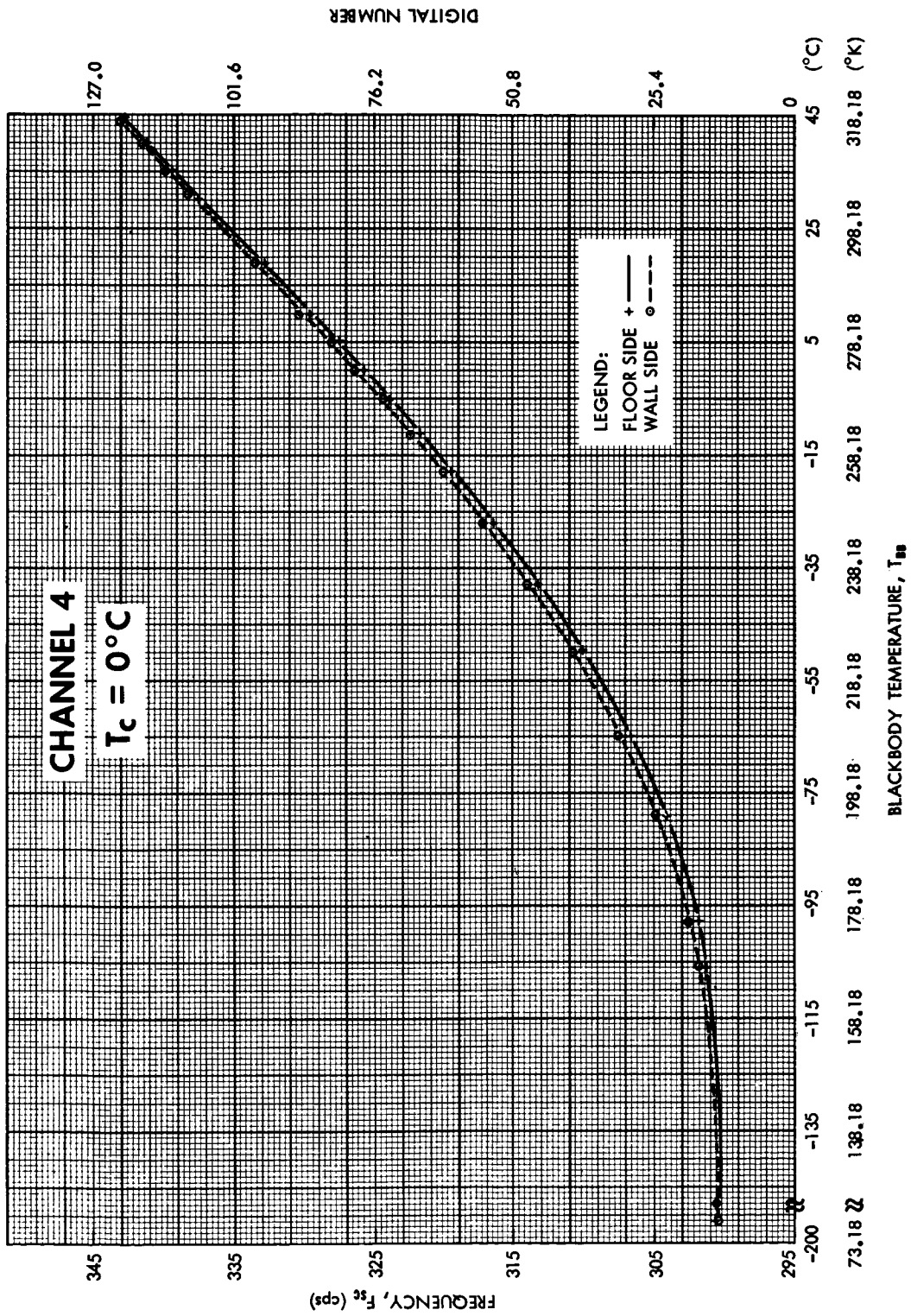


Figure 40—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 4. ( $T_c = 0^\circ\text{C}$ )



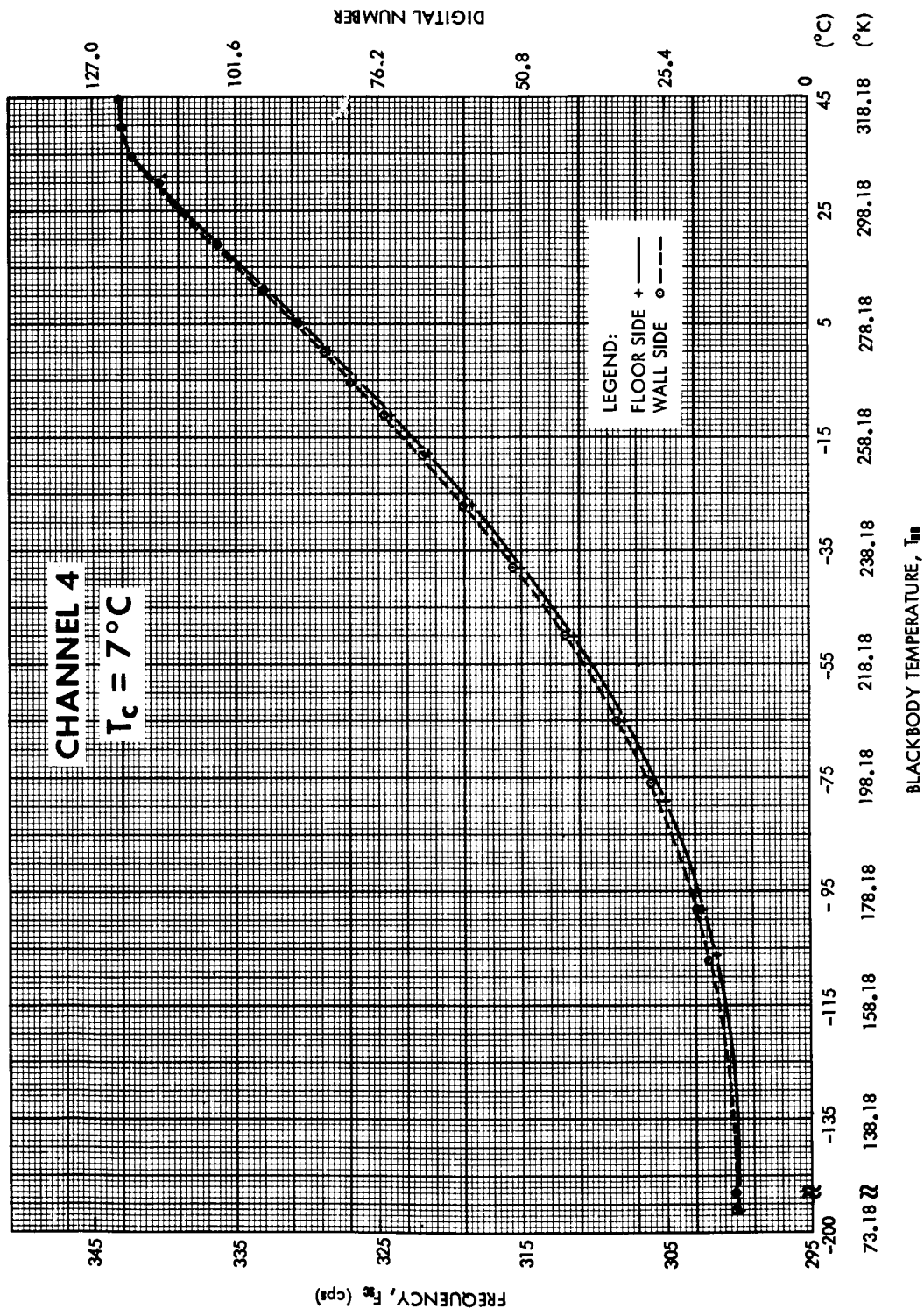


Figure 41—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 4. ( $T_c = 7^\circ\text{C}$ )

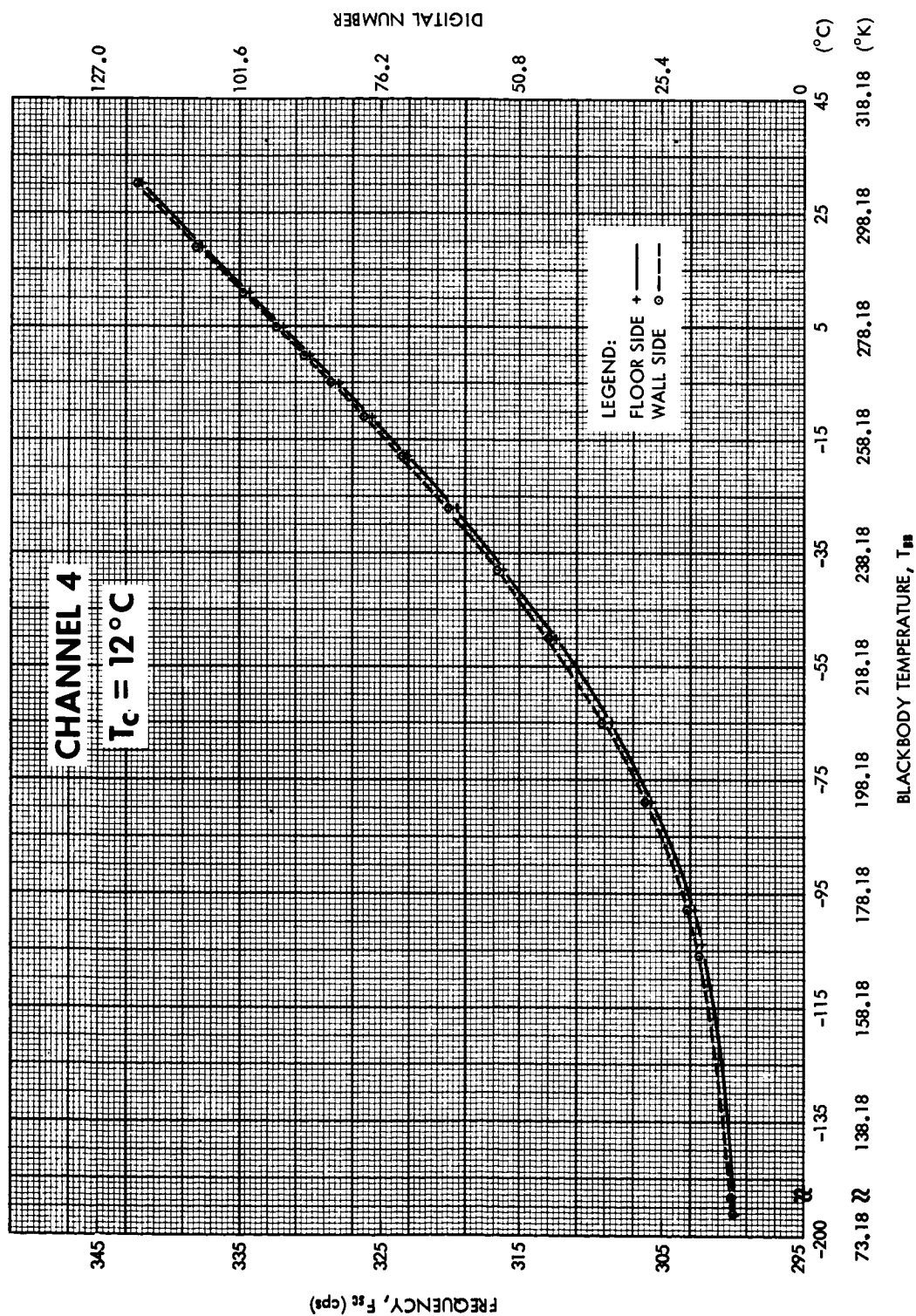


Figure 42—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 4. ( $T_c = 12^\circ\text{C}$ )



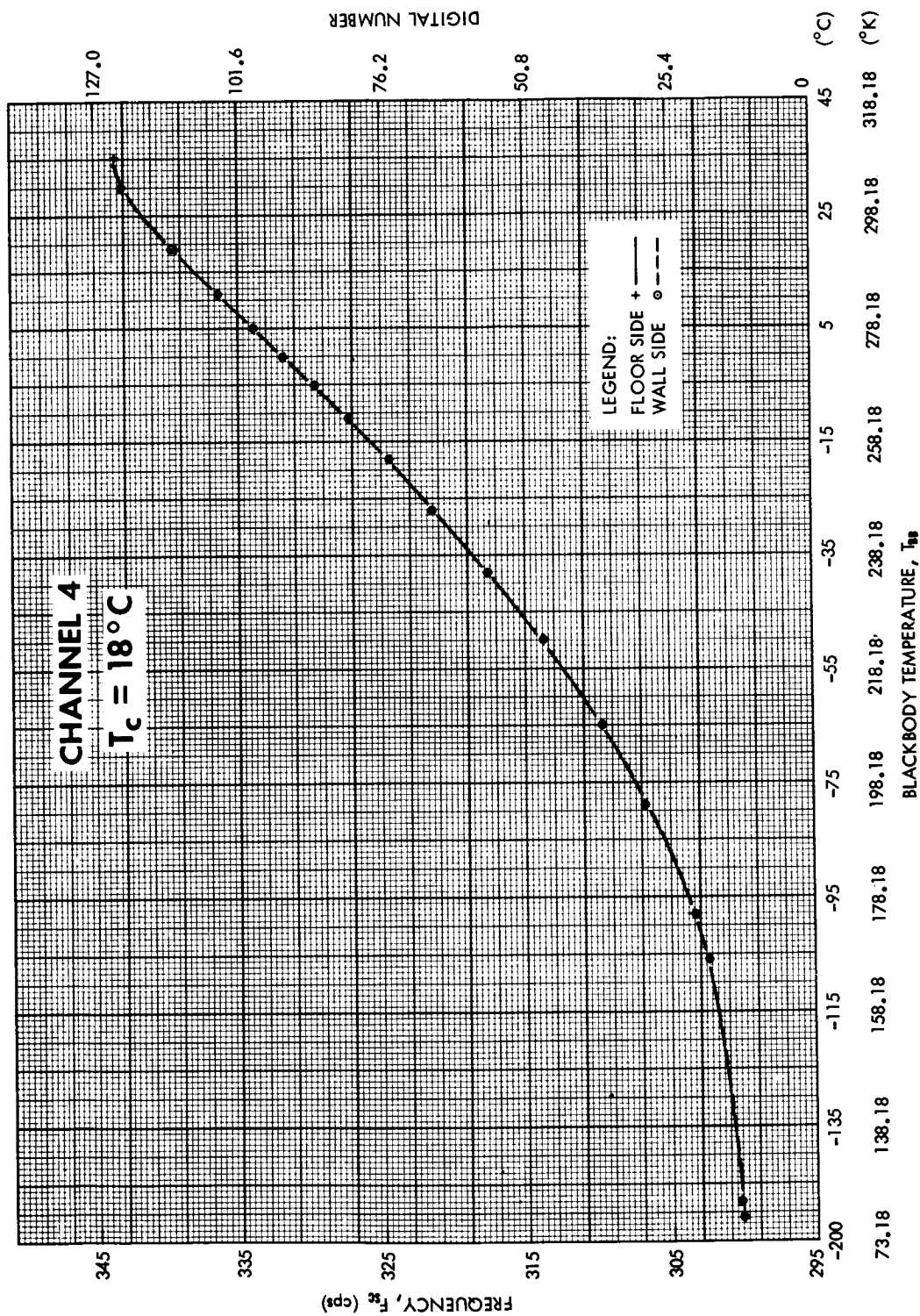


Figure 43—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 4. ( $T_c = 18^\circ\text{C}$ )

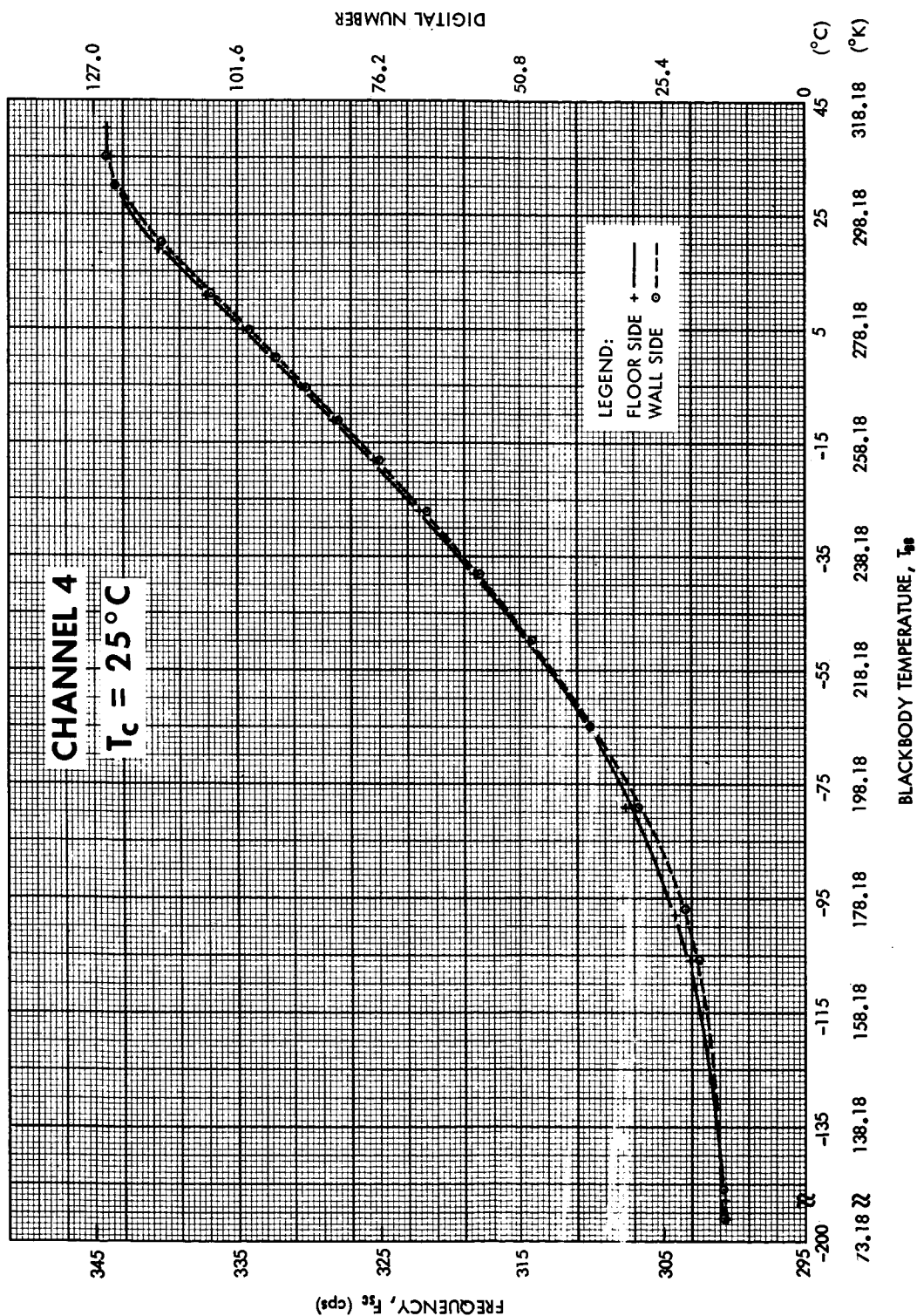


Figure 44—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 4. ( $T_c = 25^\circ\text{C}$ )

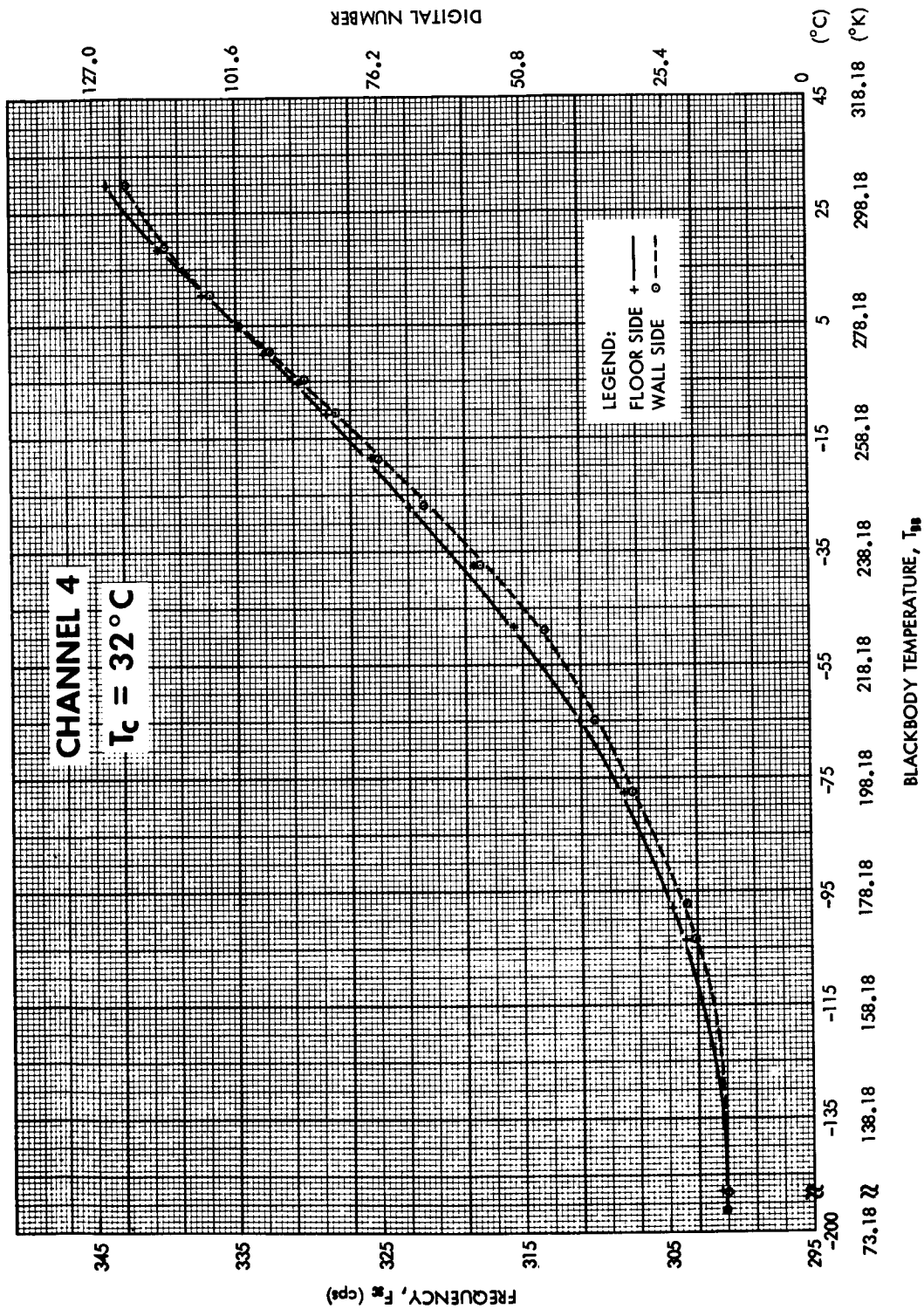


Figure 45—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 4. ( $T_c = 32^\circ\text{C}$ )

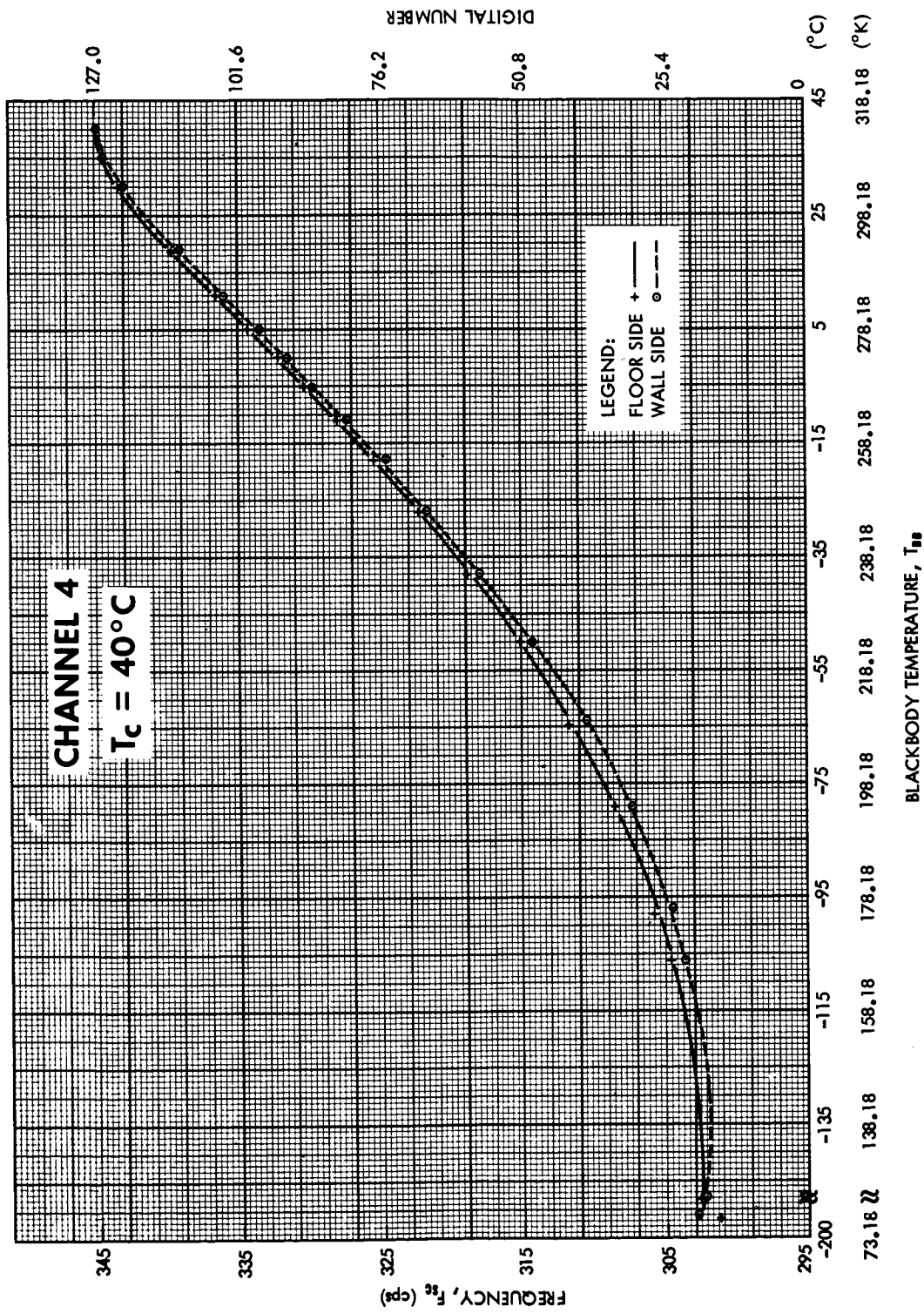


Figure 46—Subcarrier frequency and digital number versus equivalent blackbody temperature for floor and wall sides of channel 4. ( $T_c = 40^\circ\text{C}$ )

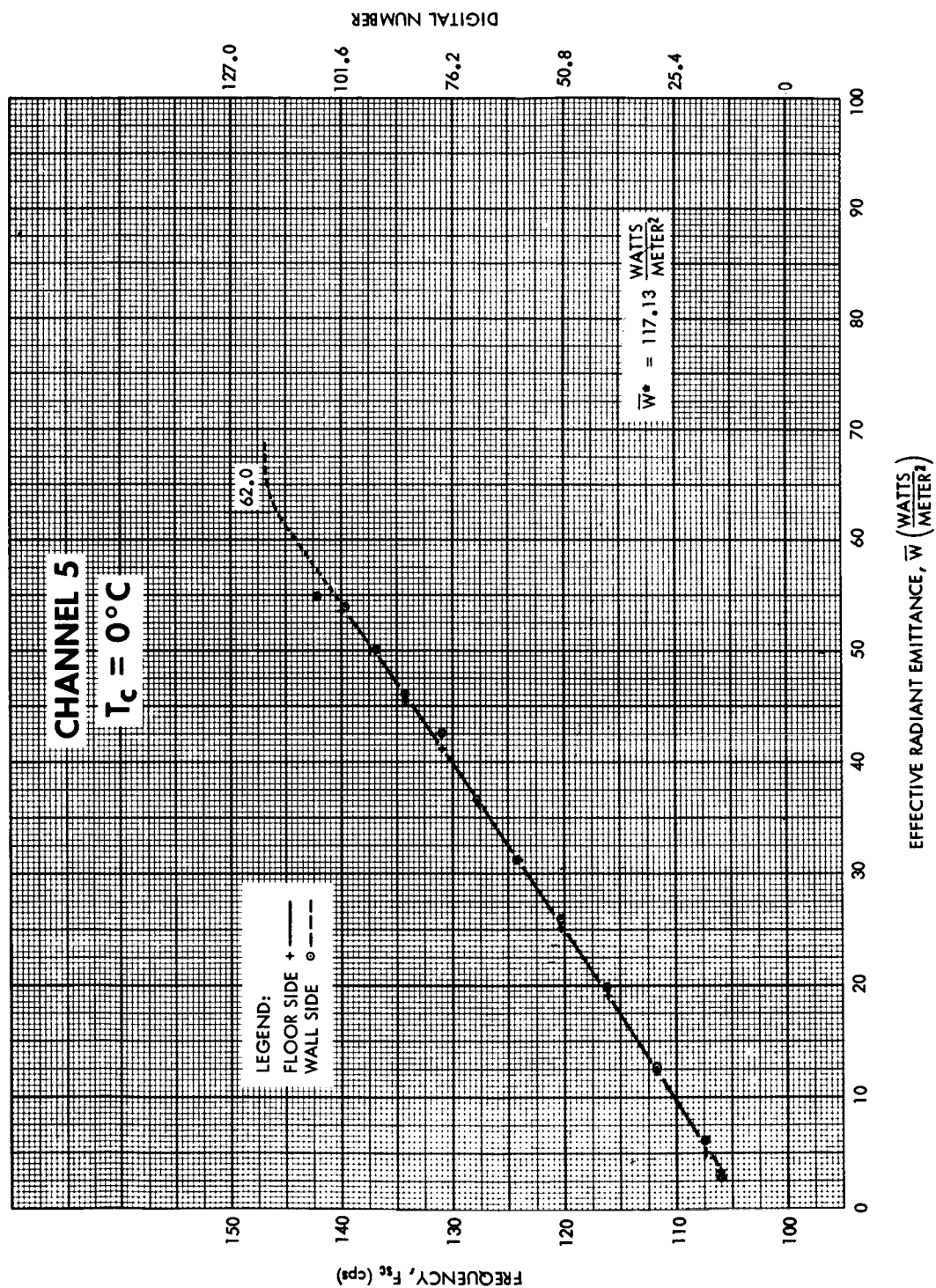


Figure 47—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 5. ( $T_c = 0^\circ\text{C}$ )

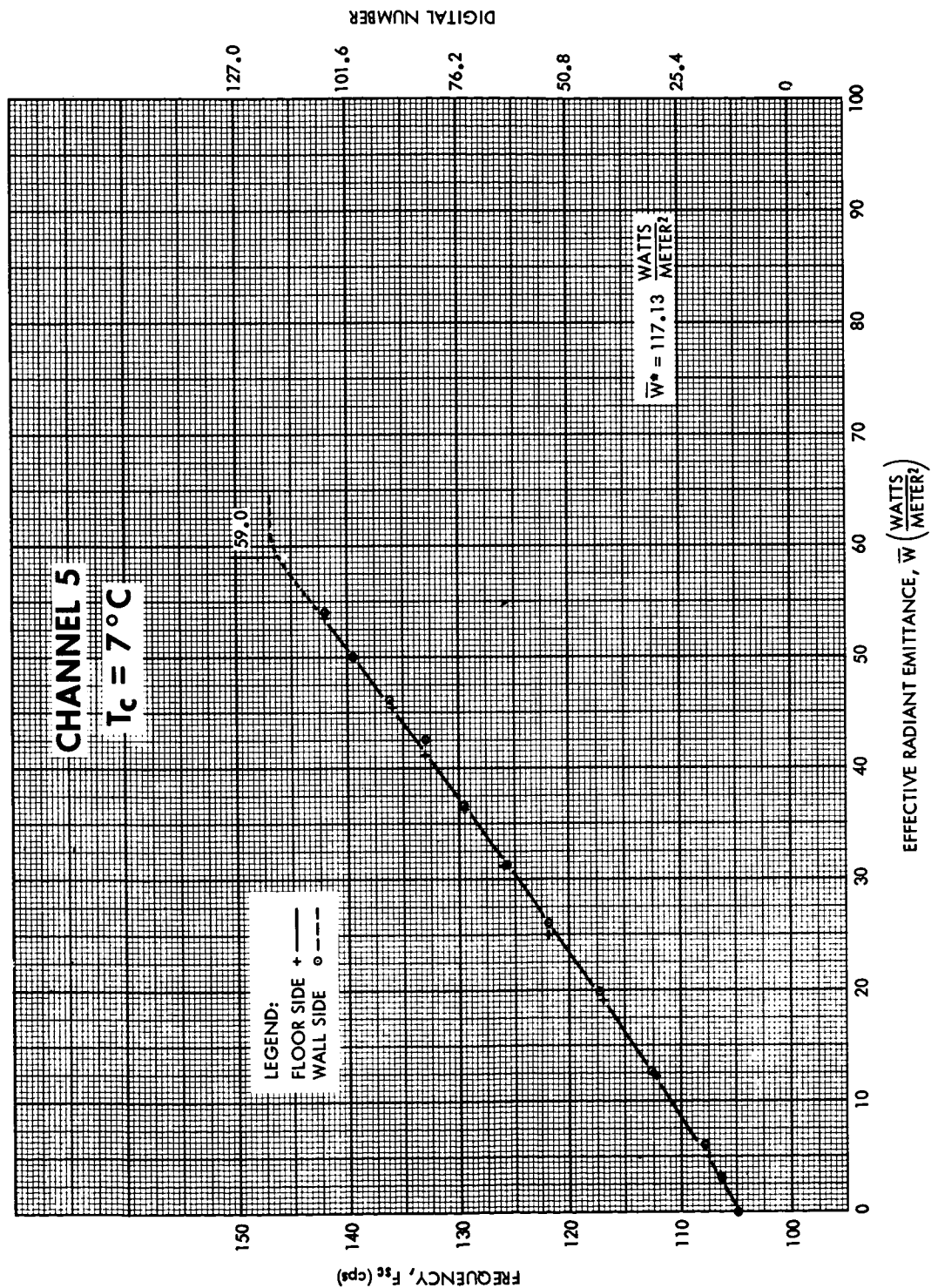


Figure 48—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 5. ( $T_c = 7^\circ\text{C}$ )



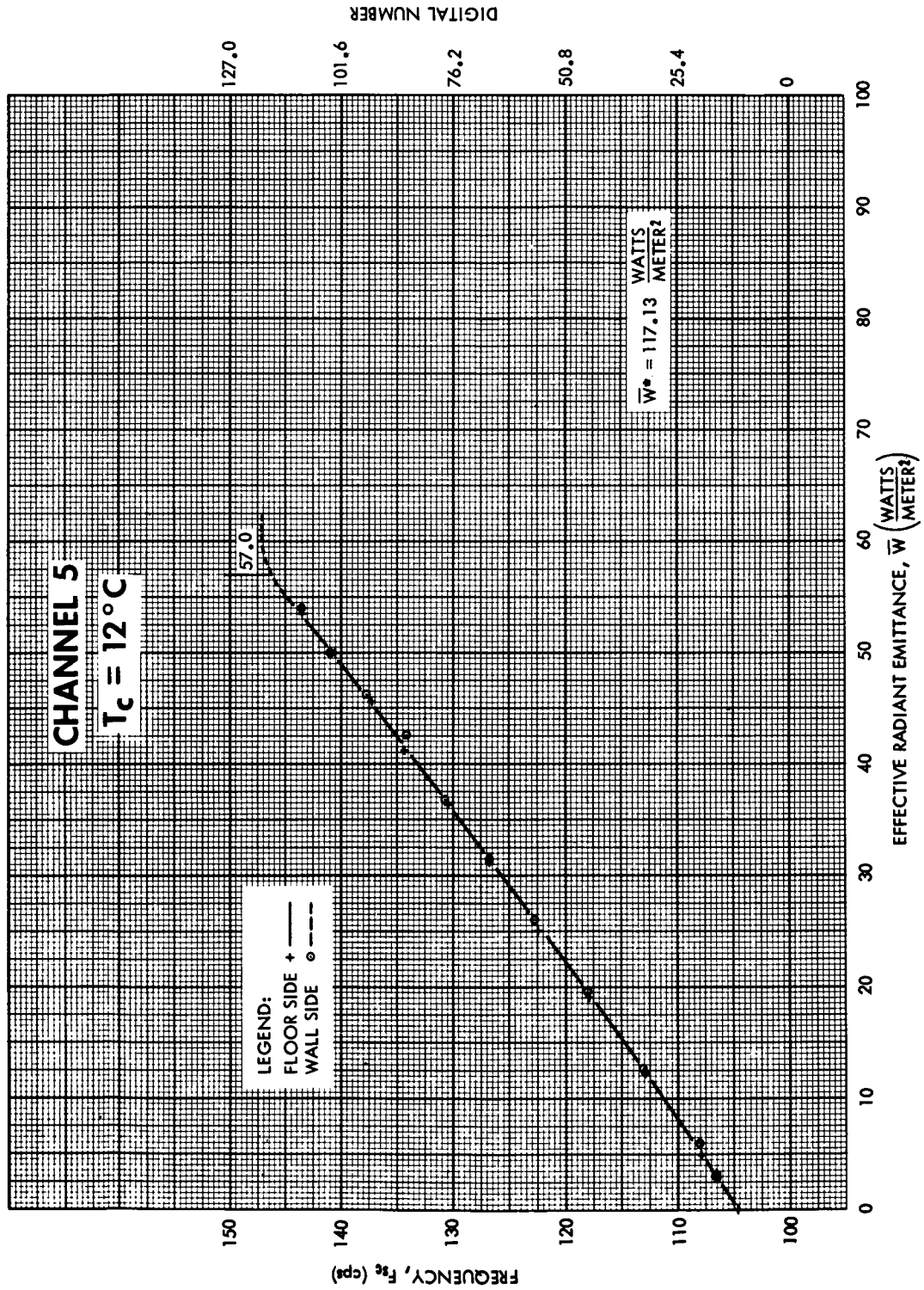


Figure 49—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 5. ( $T_c = 12^\circ\text{C}$ )

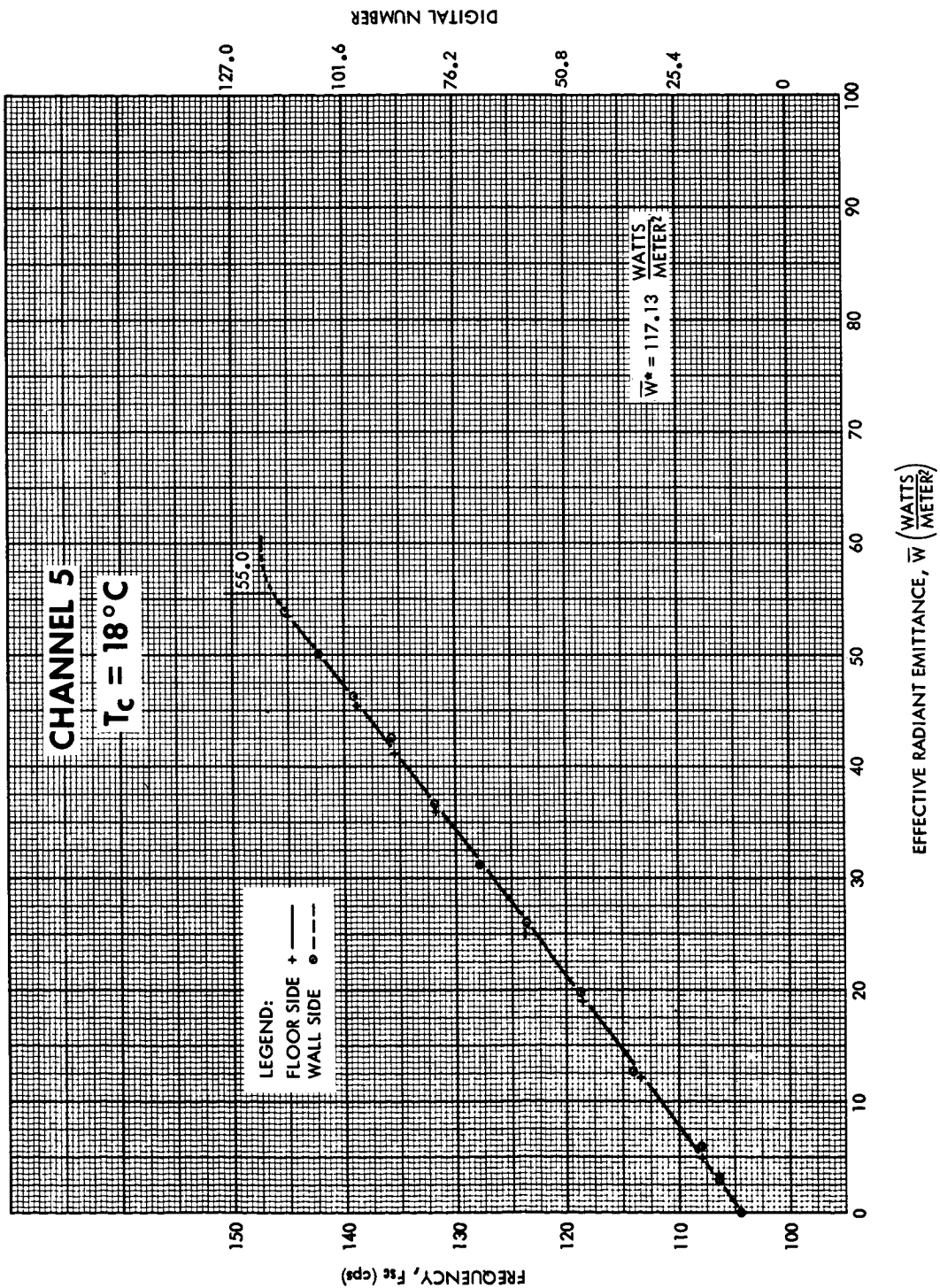


Figure 50—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 5. ( $T_c = 18^\circ\text{C}$ )



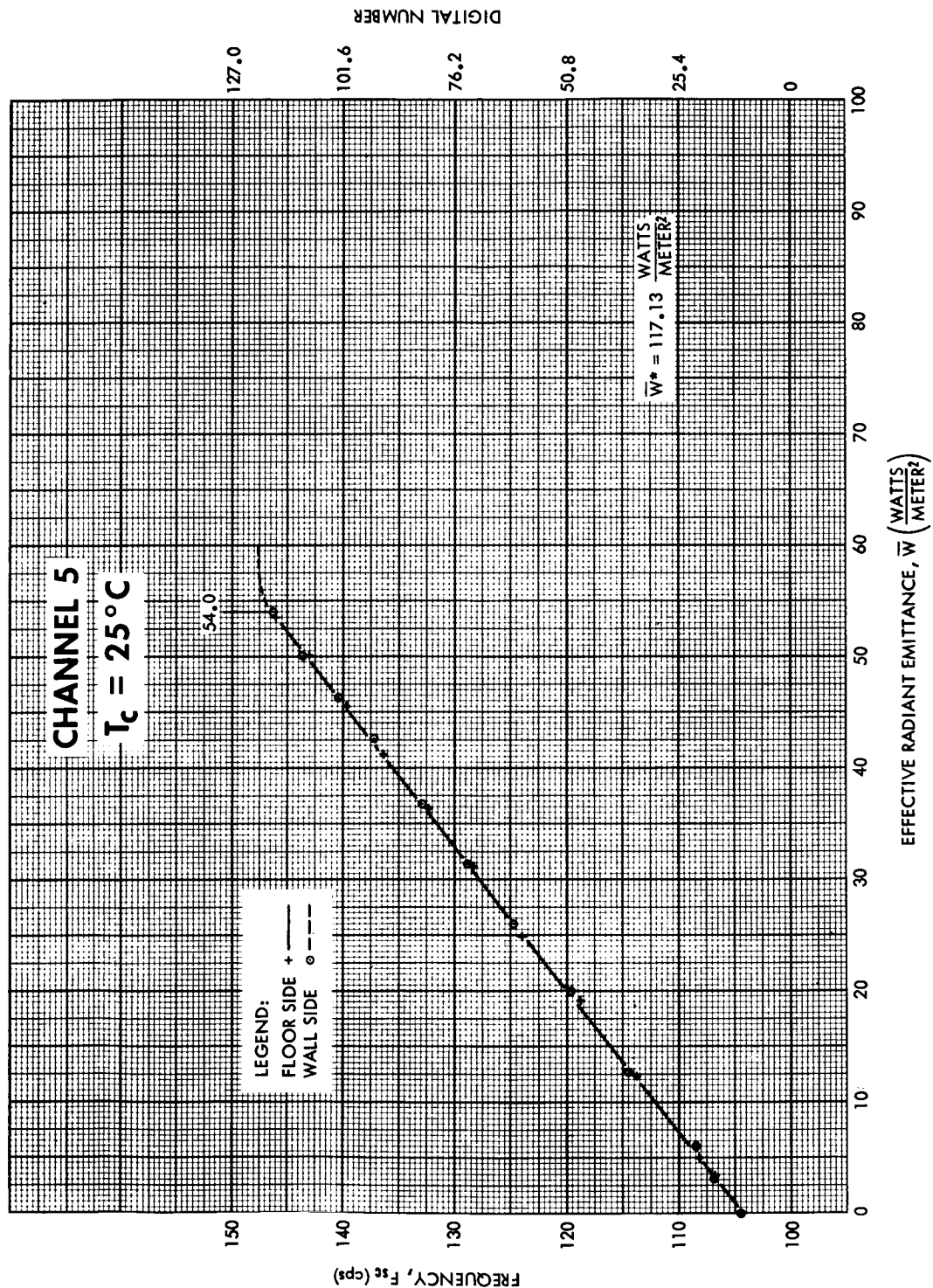


Figure 51—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 5. ( $T_c = 25^\circ\text{C}$ )

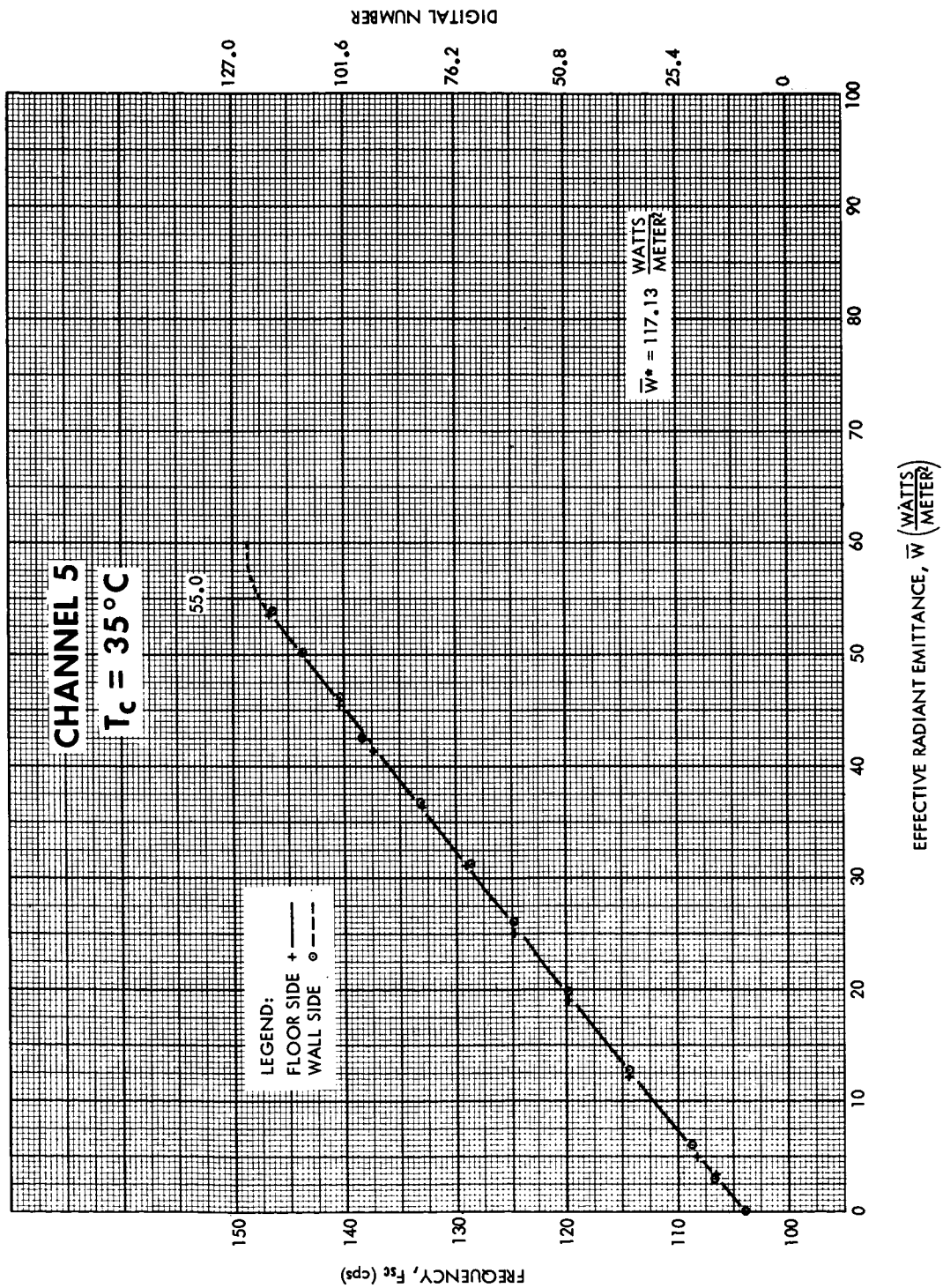


Figure 52—Subcarriers frequency and digital number versus effective radiant emittance for floor and wall sides of channel 5. ( $T_c = 35^\circ\text{C}$ )

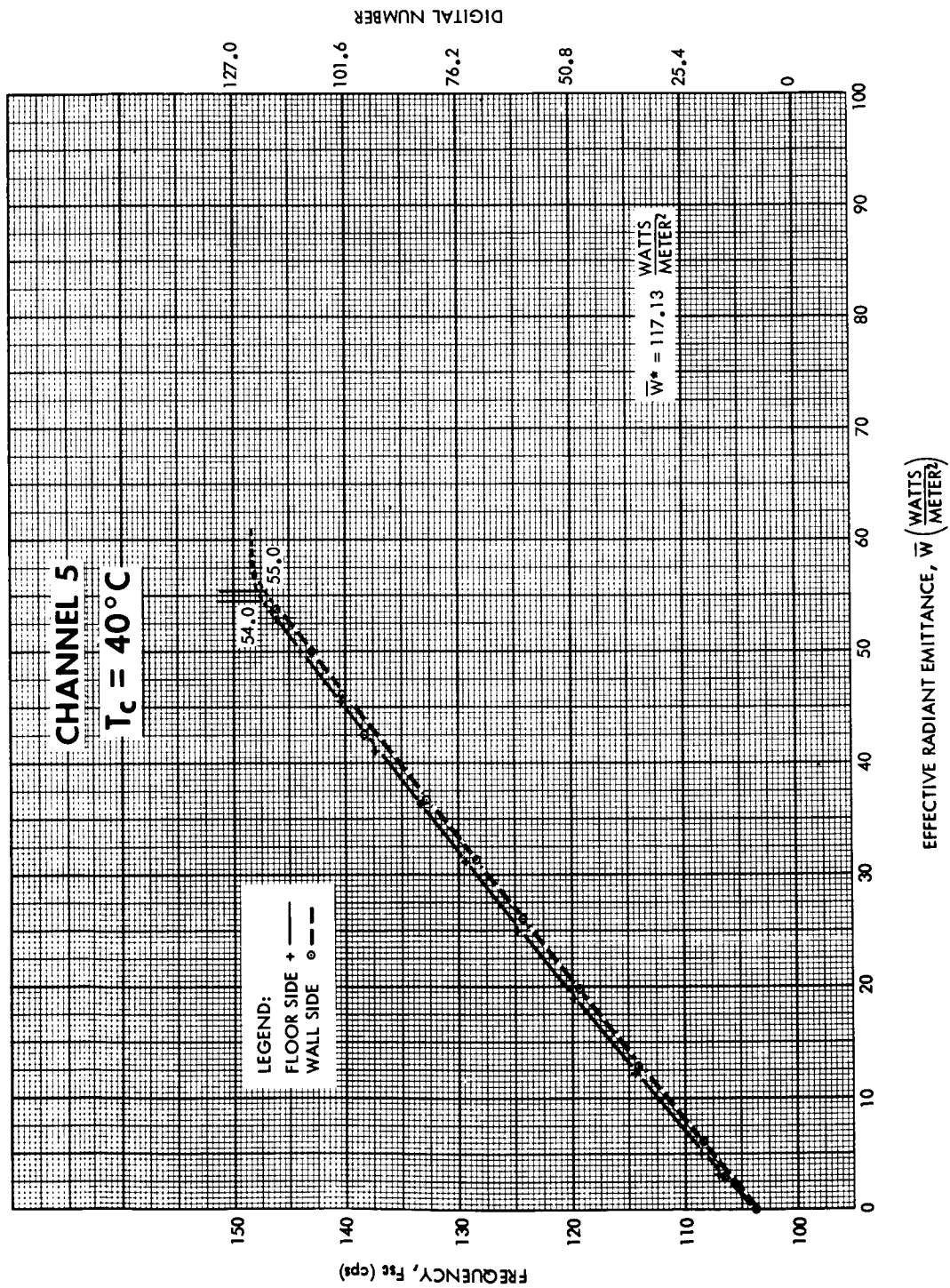
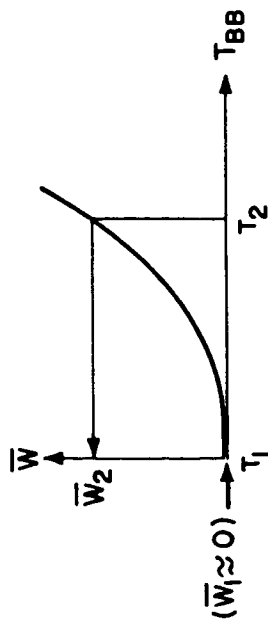


Figure 53—Subcarrier frequency and digital number versus effective radiant emittance for floor and wall sides of channel 5. ( $T_c = 40^\circ\text{C}$ )

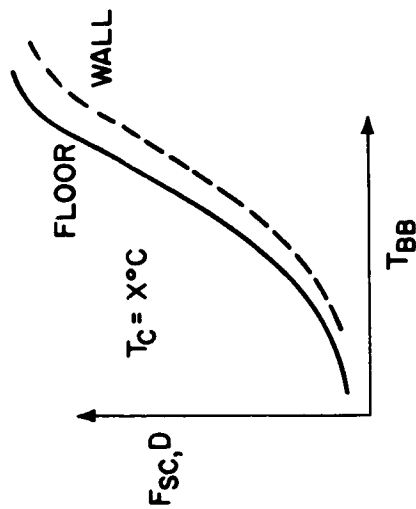
# THERMAL CHANNELS 1, 2, AND 4



REFERENCE TARGET AT TEMPERATURE

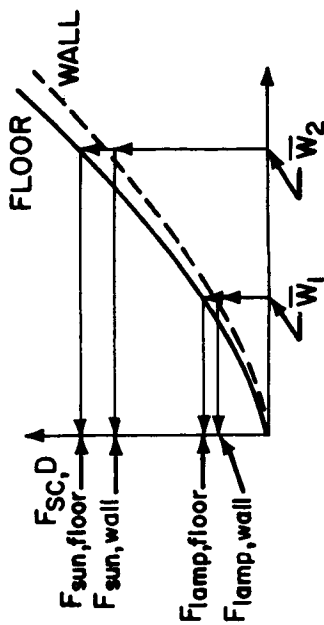
$T_1$  ( $-196^{\circ}\text{C}$ )

"HOT" TARGET AT TEMPERATURE  $T_2$



(a)

# VISIBLE CHANNELS 3 AND 5



DIFFUSE SOURCE :

$$\bar{W} = \frac{\cos \gamma}{R^2} \int_0^{\infty} J_{\lambda} \phi_{\lambda} r_{\lambda} d\lambda$$

SUN AT NORMAL INCIDENCE ON  
SURFACE OF UNIT REFLECTIVITY

$$\bar{W}^* = \frac{\Omega}{\pi} \int_0^{\infty} W_{\lambda}(T) \phi_{\lambda} d\lambda$$

(b)

Figure 54—(a) Calibration of the emitted thermal radiation channels 1, 2, and 4.  
(b) Calibration of the reflected solar radiation channels 3 and 5.

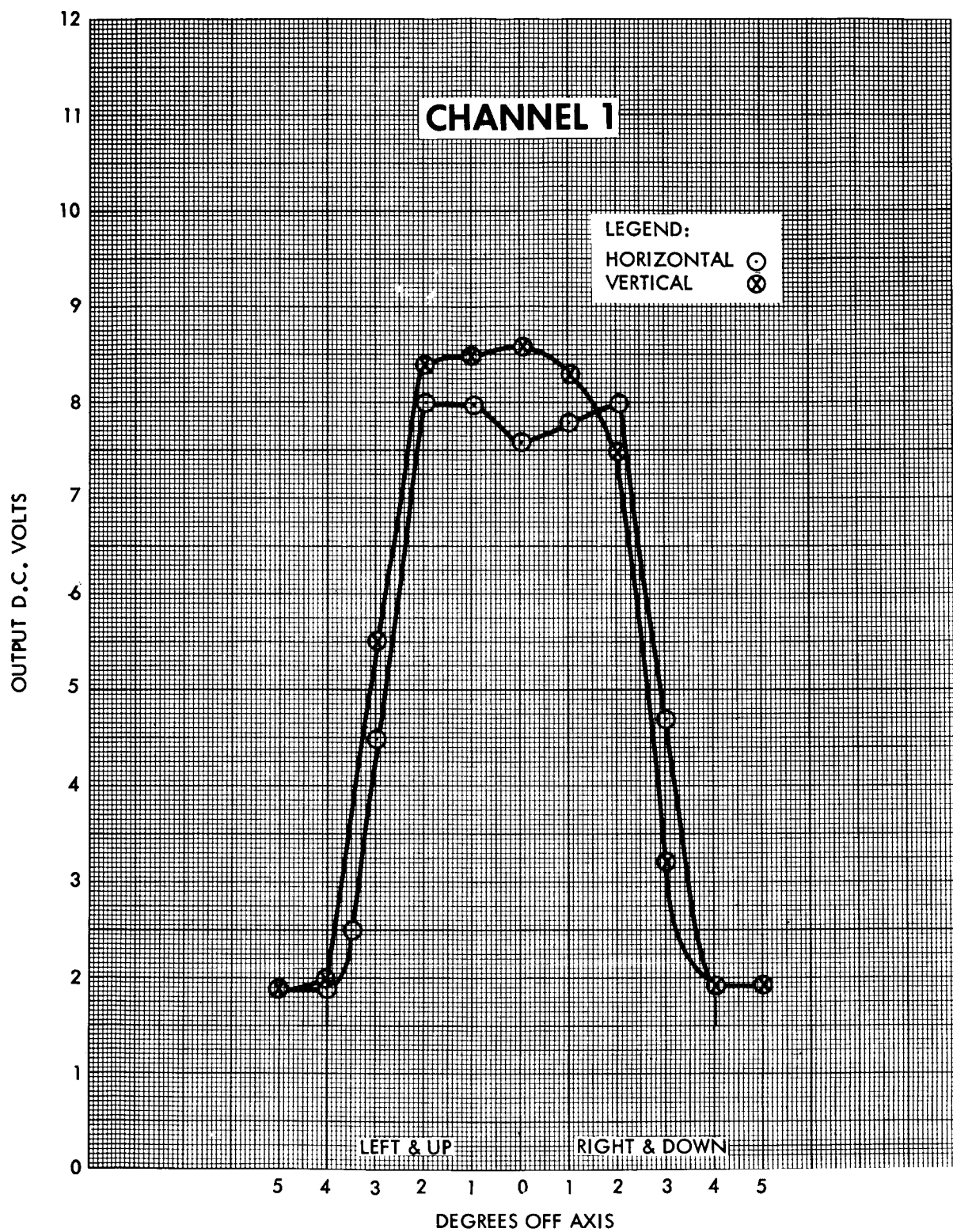


Figure 55—Field of view measurements for channel 1.

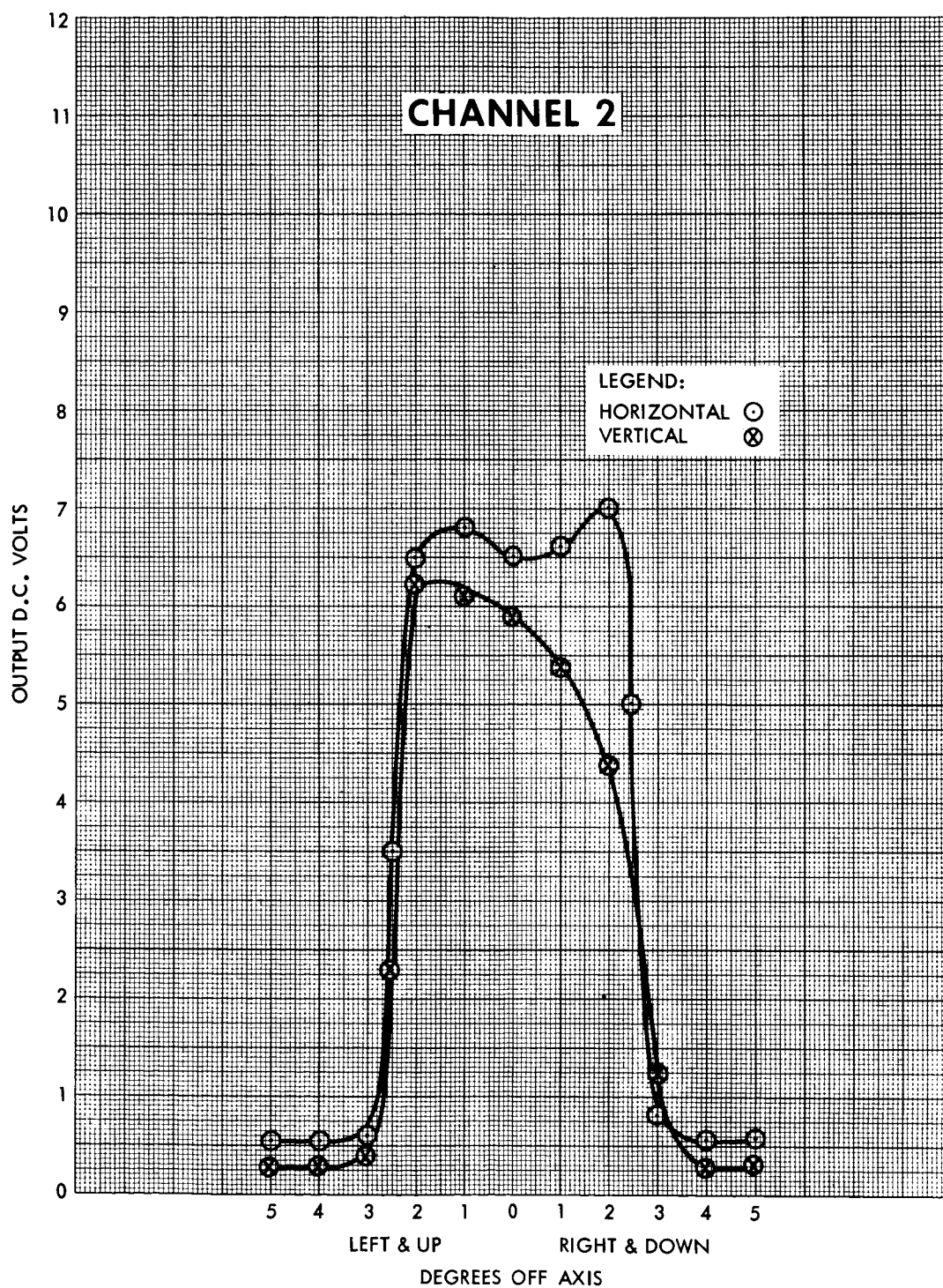


Figure 56—Field of view measurements for channel 2.



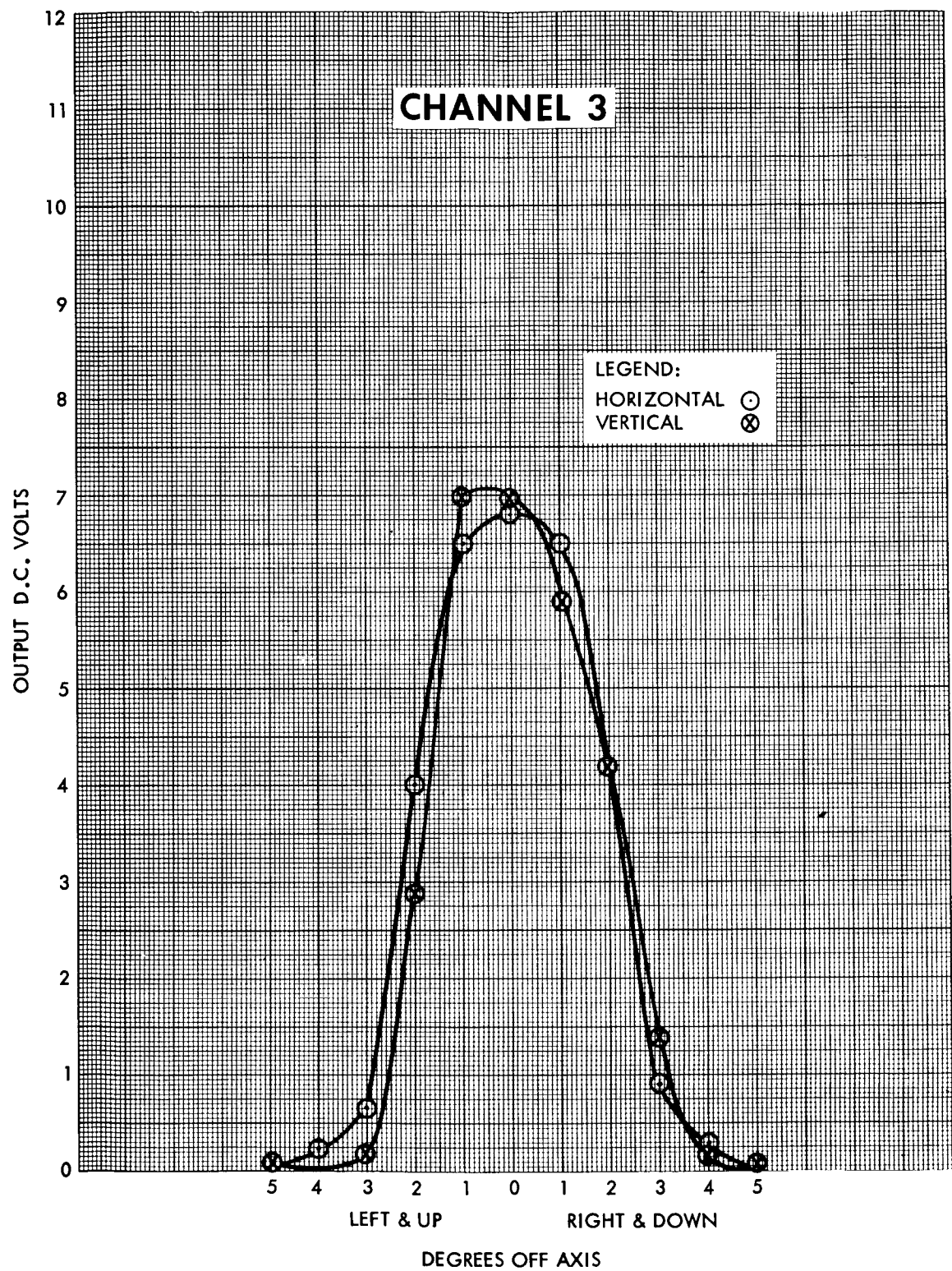


Figure 57—Field of view measurements for channel 3.

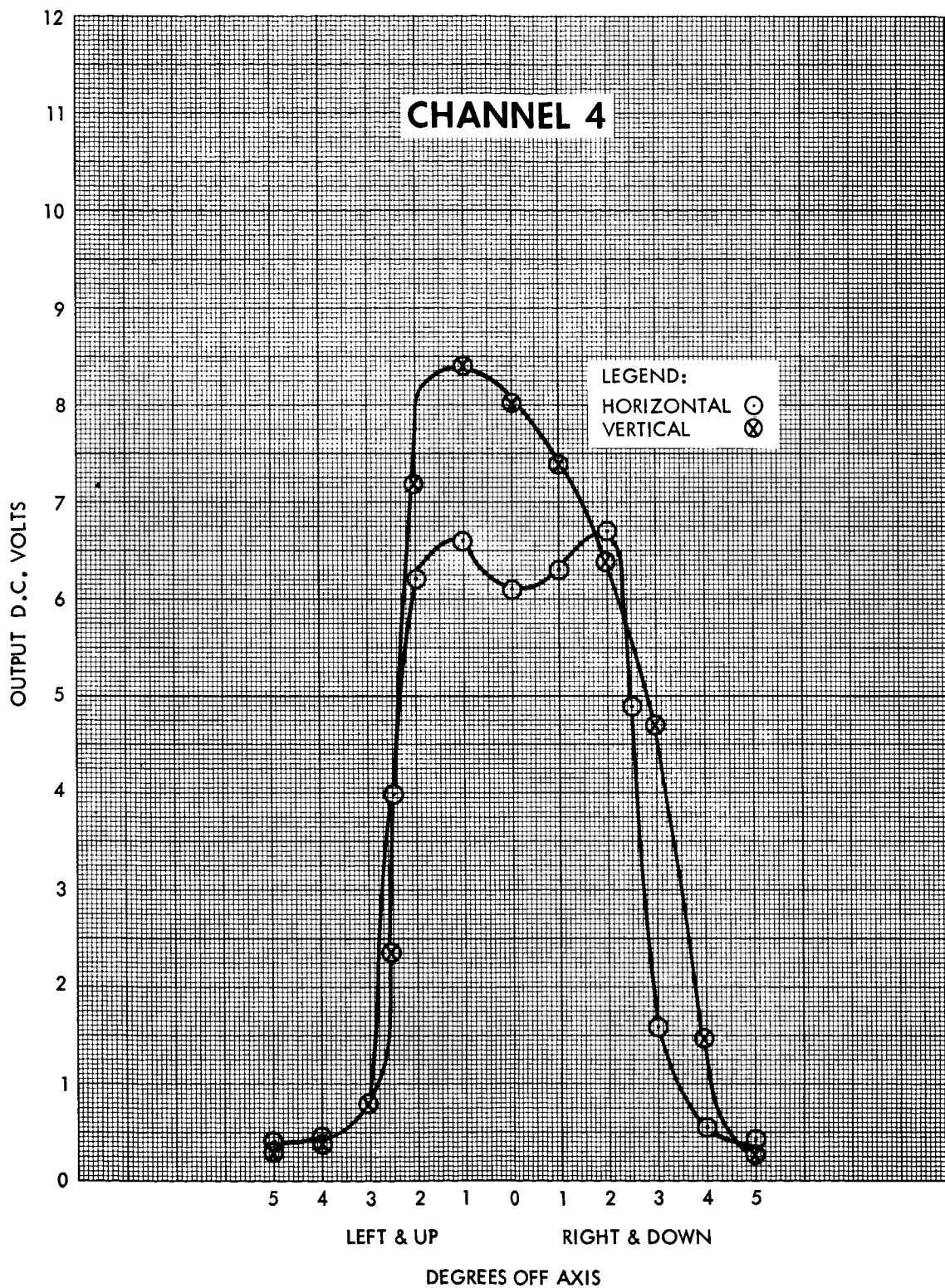


Figure 58—Field of view measurements for channel 4.



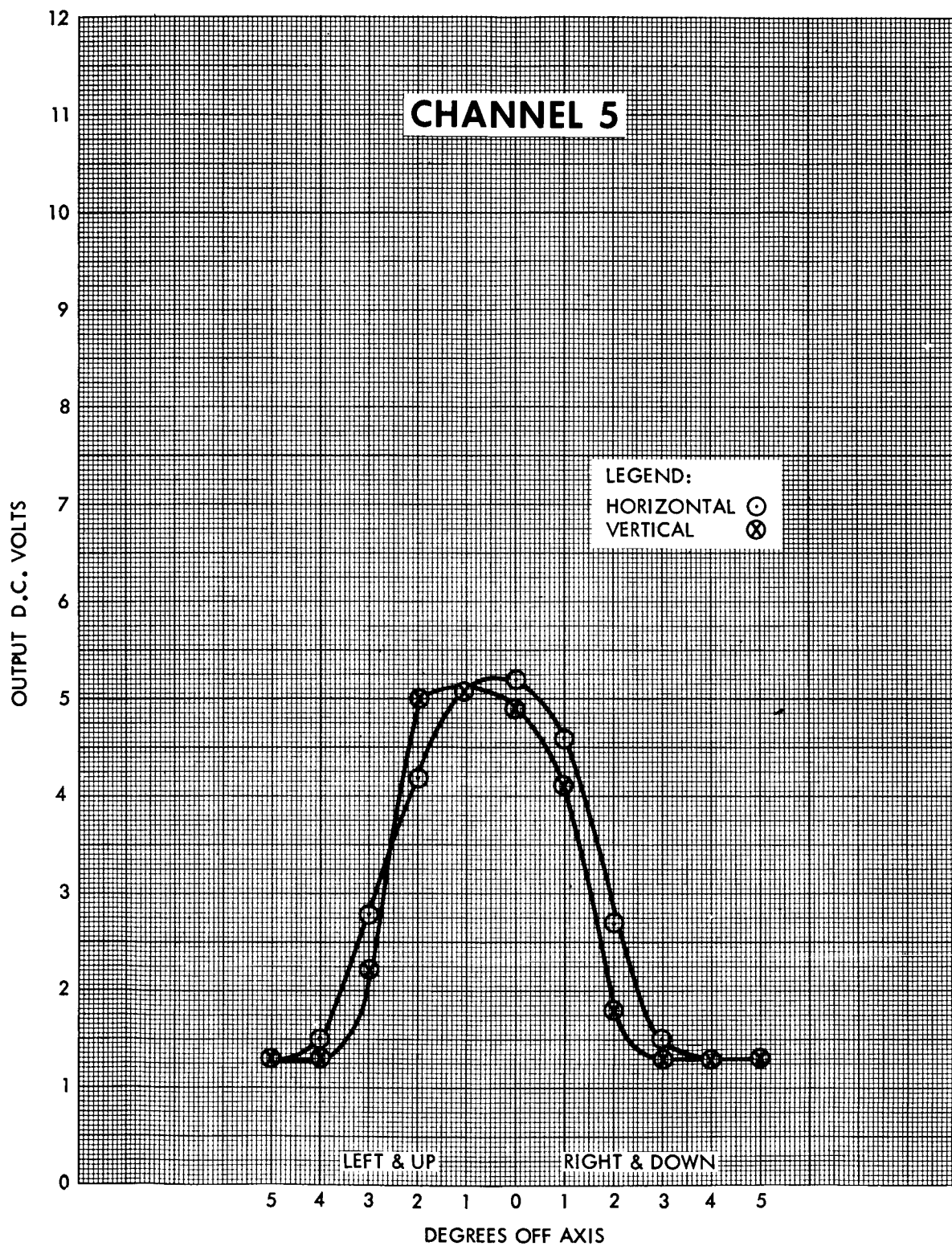


Figure 59—Field of view measurements for channel 5.

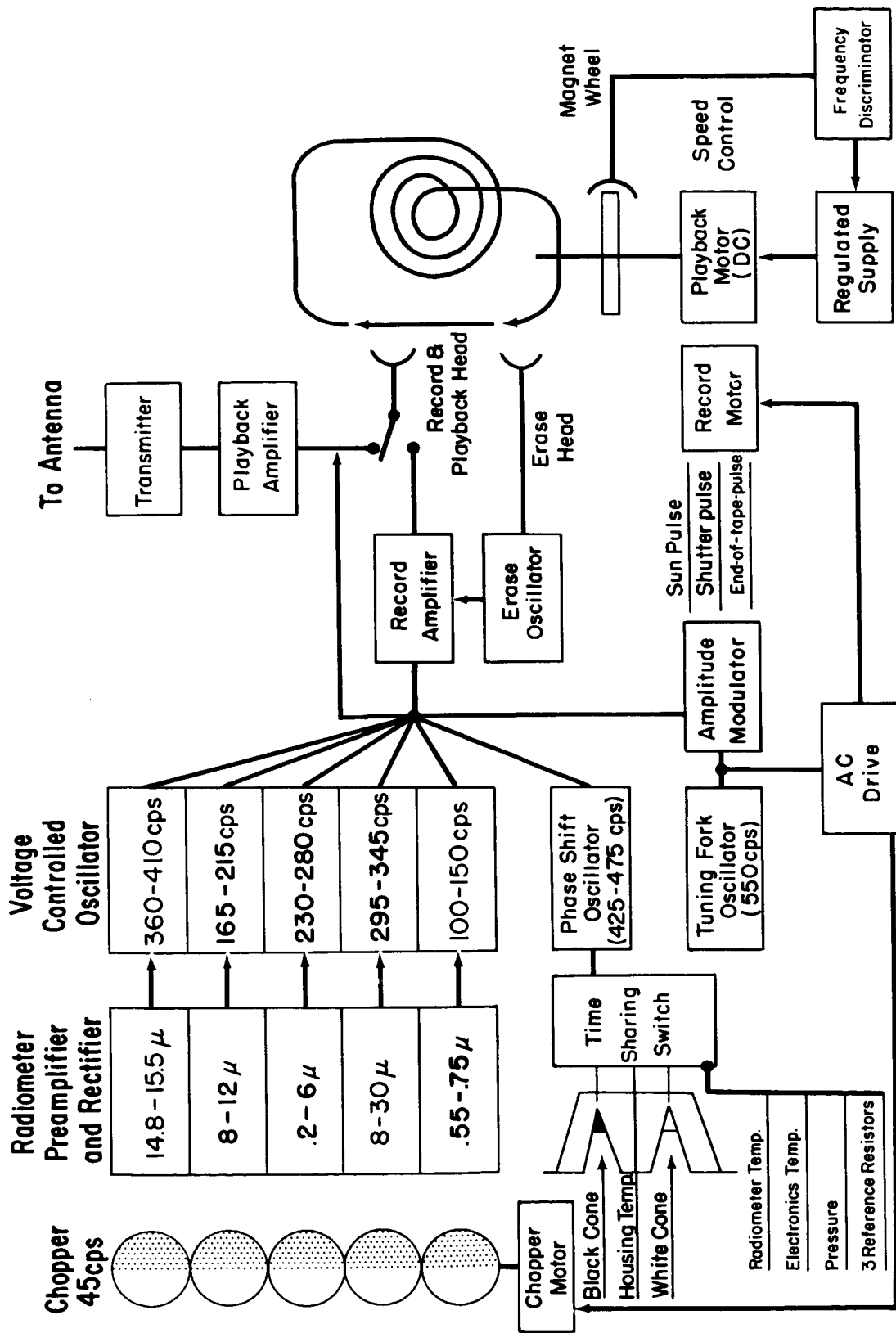


Figure 60—Block diagram of the radiation experiment in the satellite.

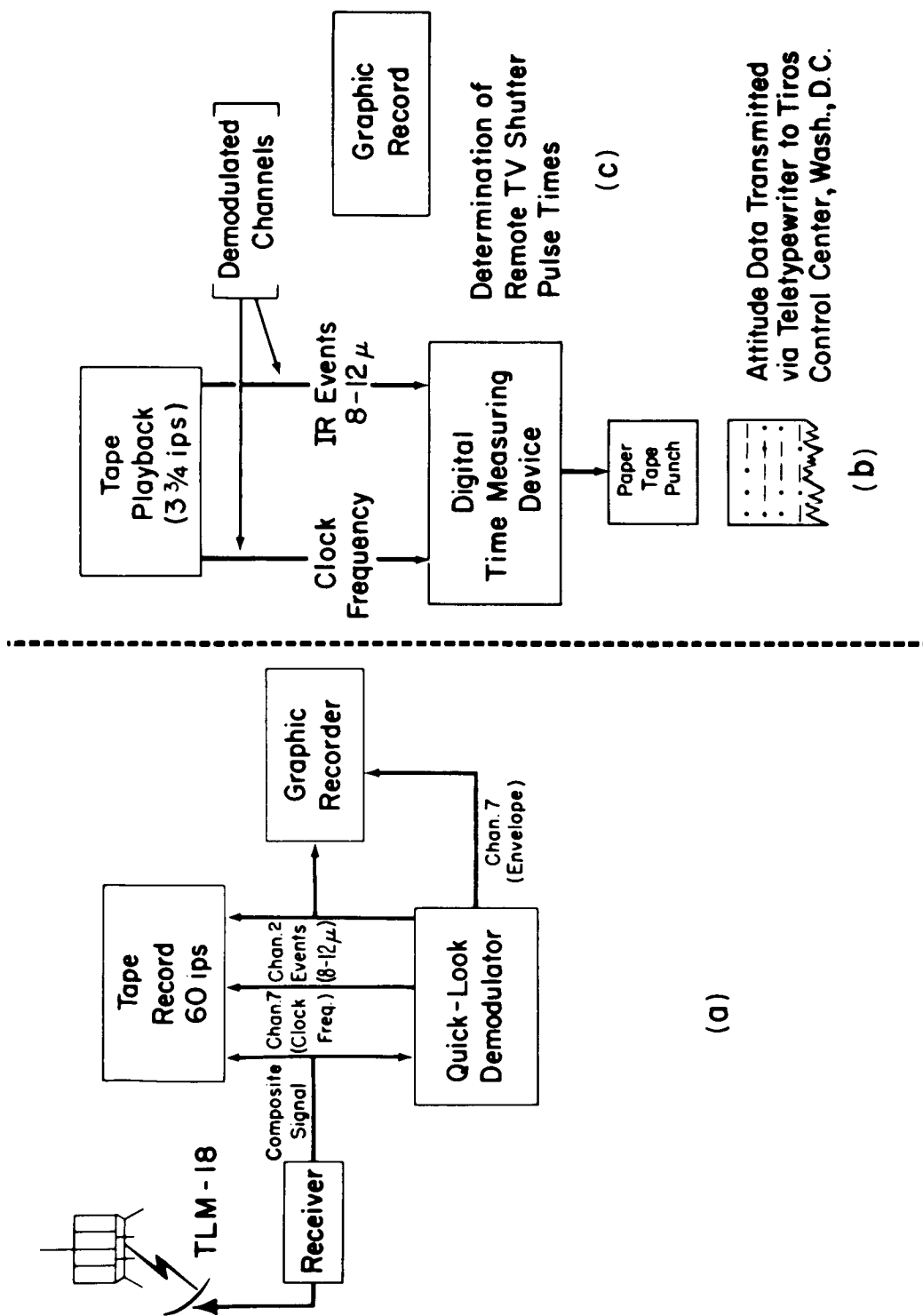


Figure 61—Block diagram of information flow at the Command and Data Acquisition Station including auxiliary uses of the radiation data.

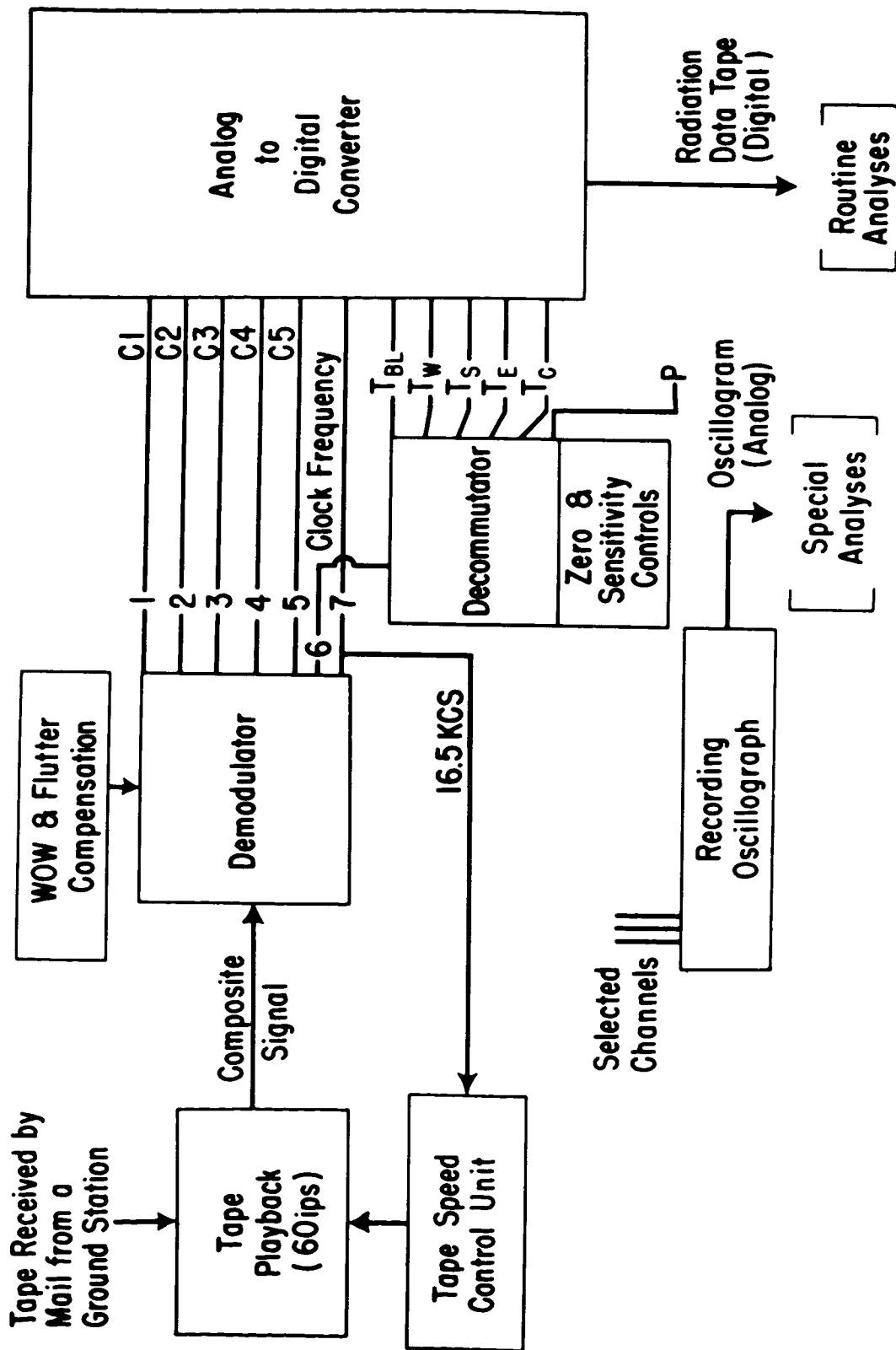


Figure 62—Block diagram of information flow at the Data Processing Center in producing a digital magnetic tape for computer input.

## ONE FILE (ONE ORBIT)

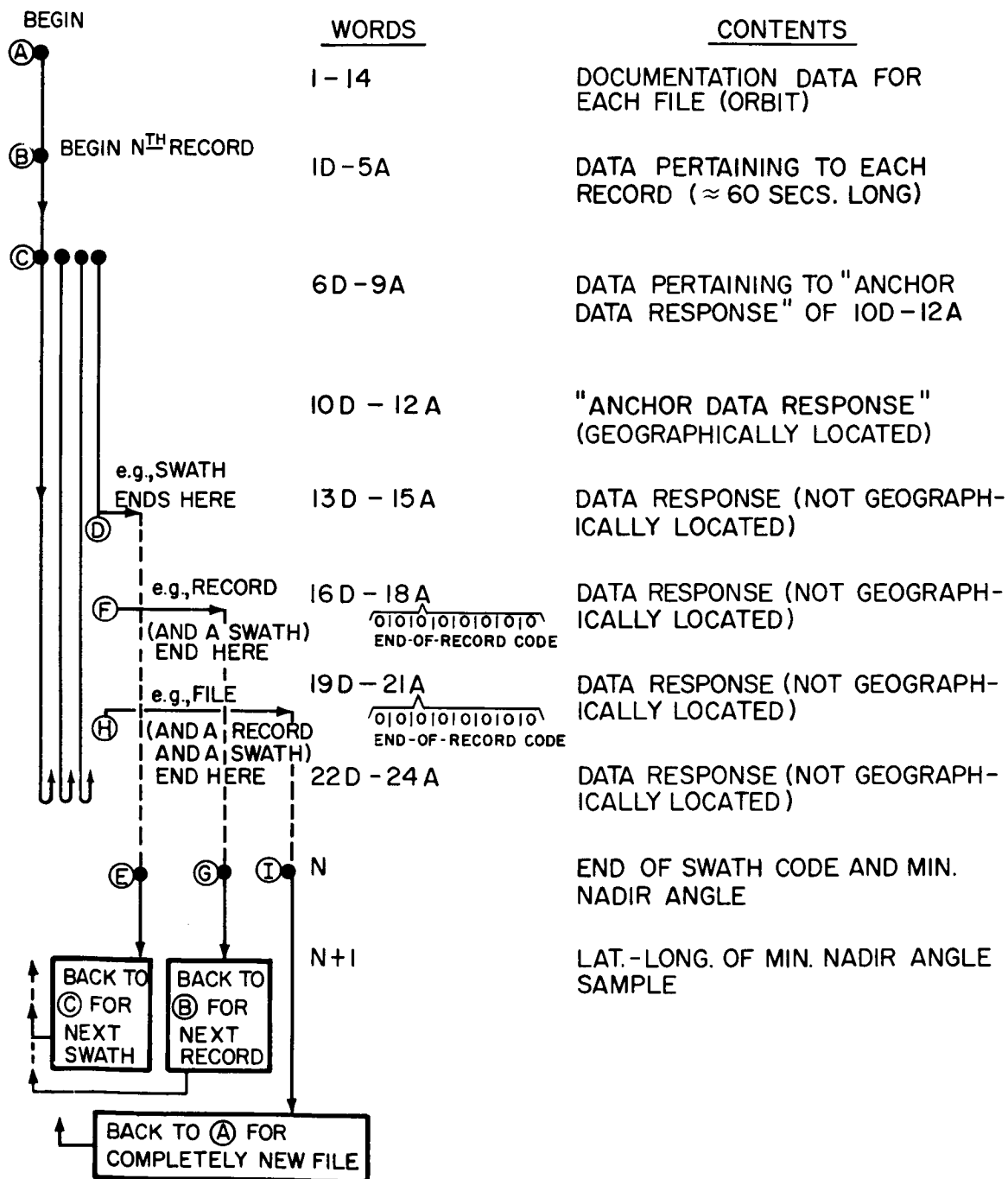


Figure 63—Diagram for interpretation of the FMR tape format.

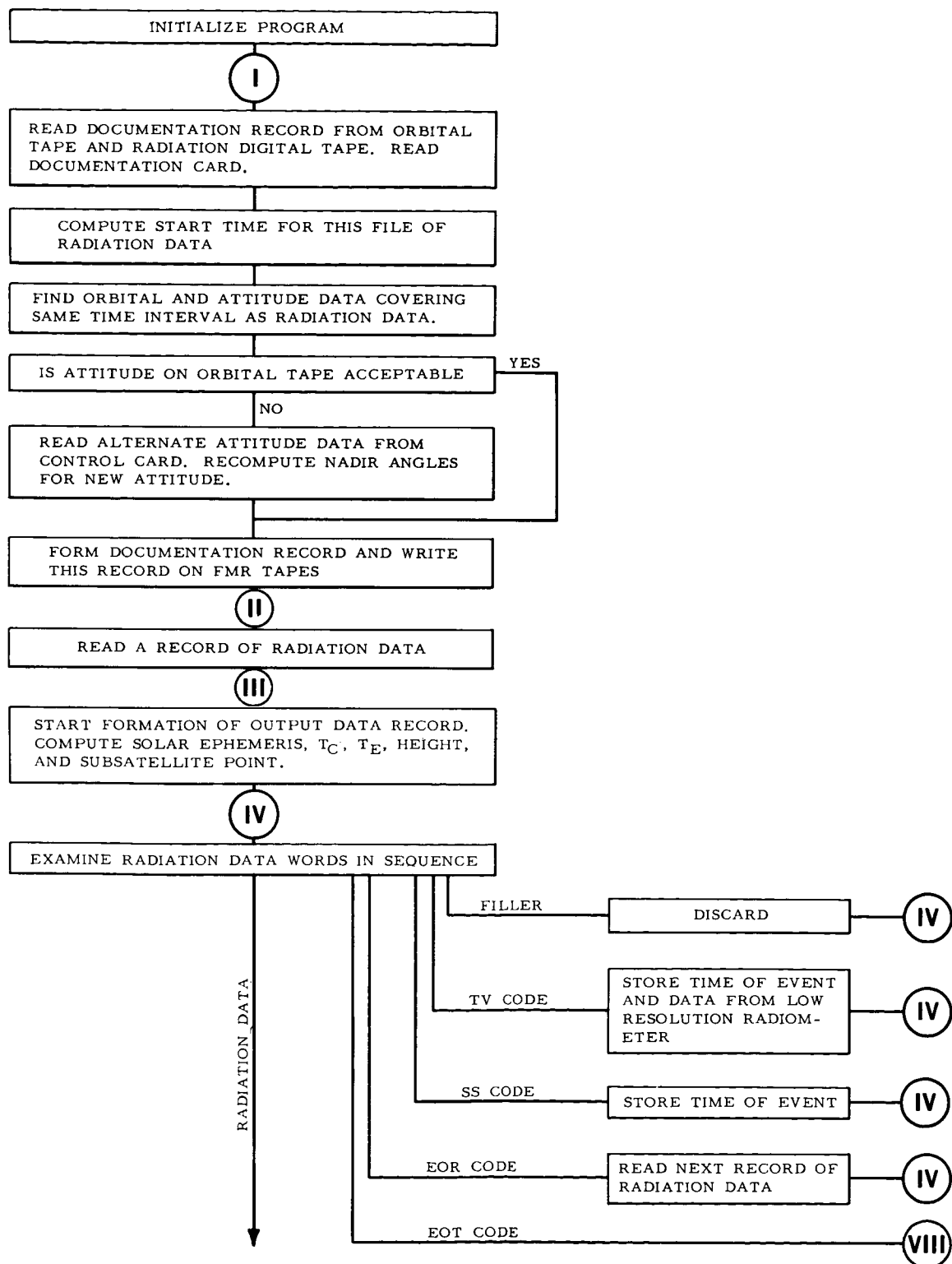
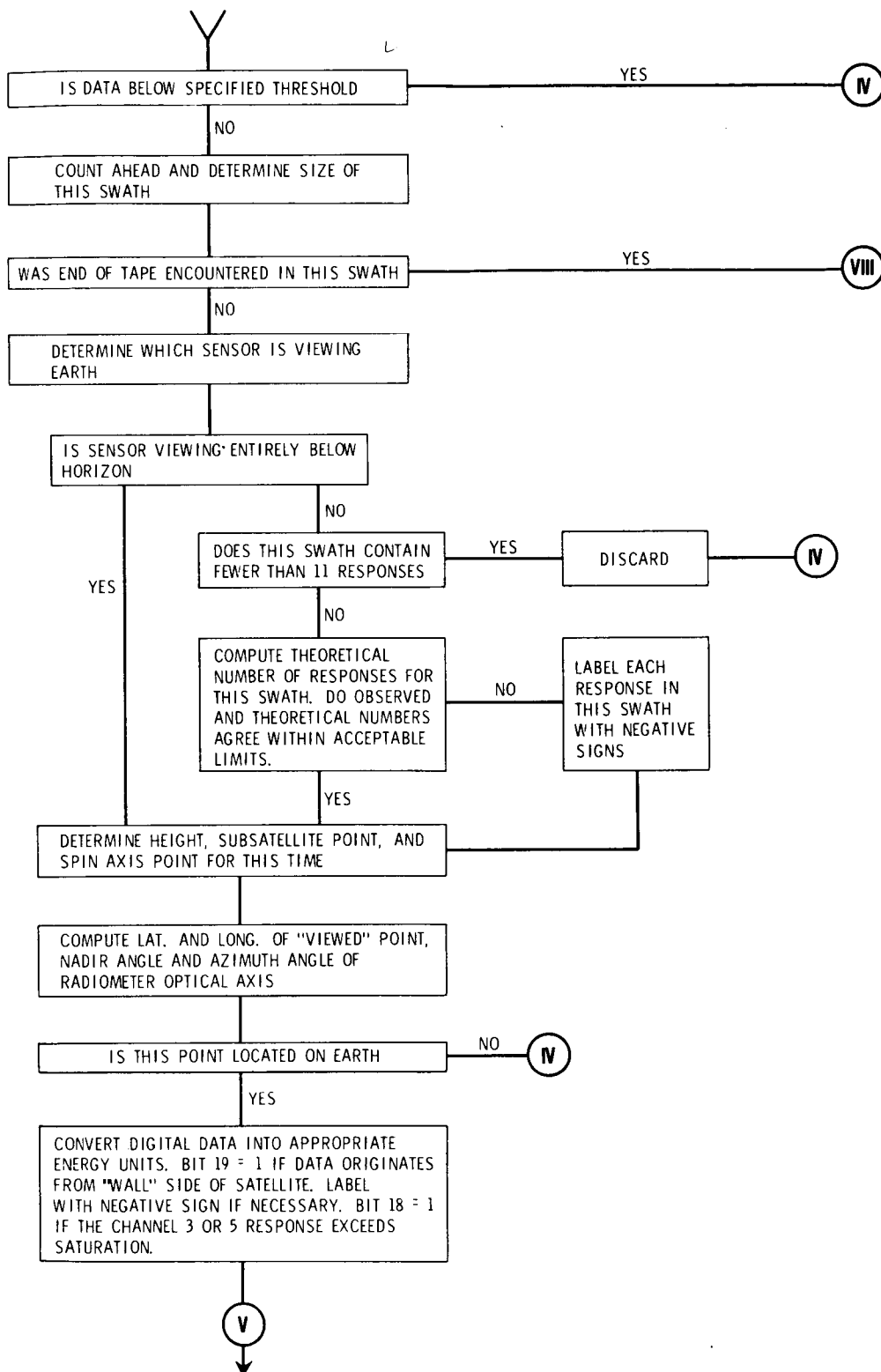
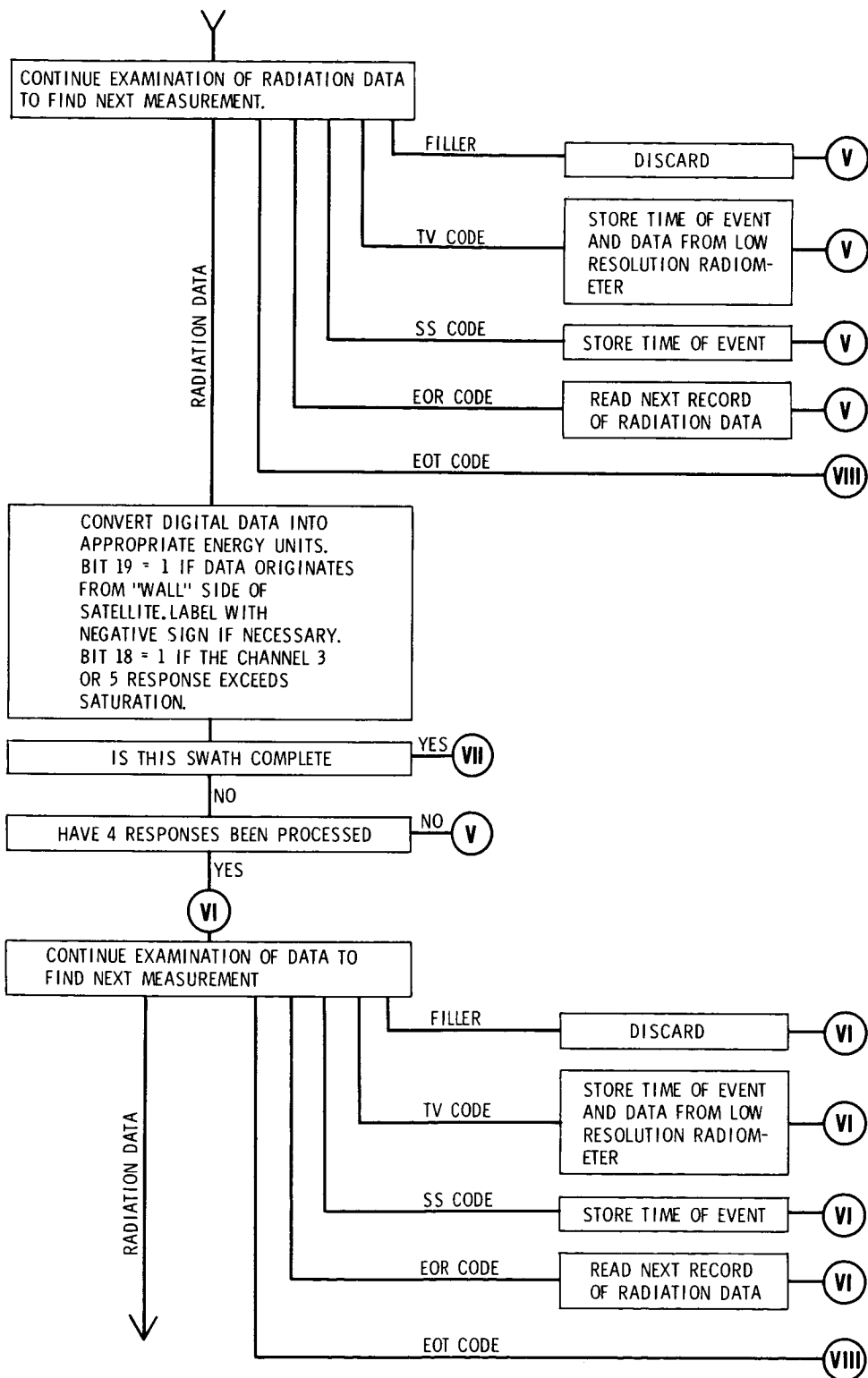
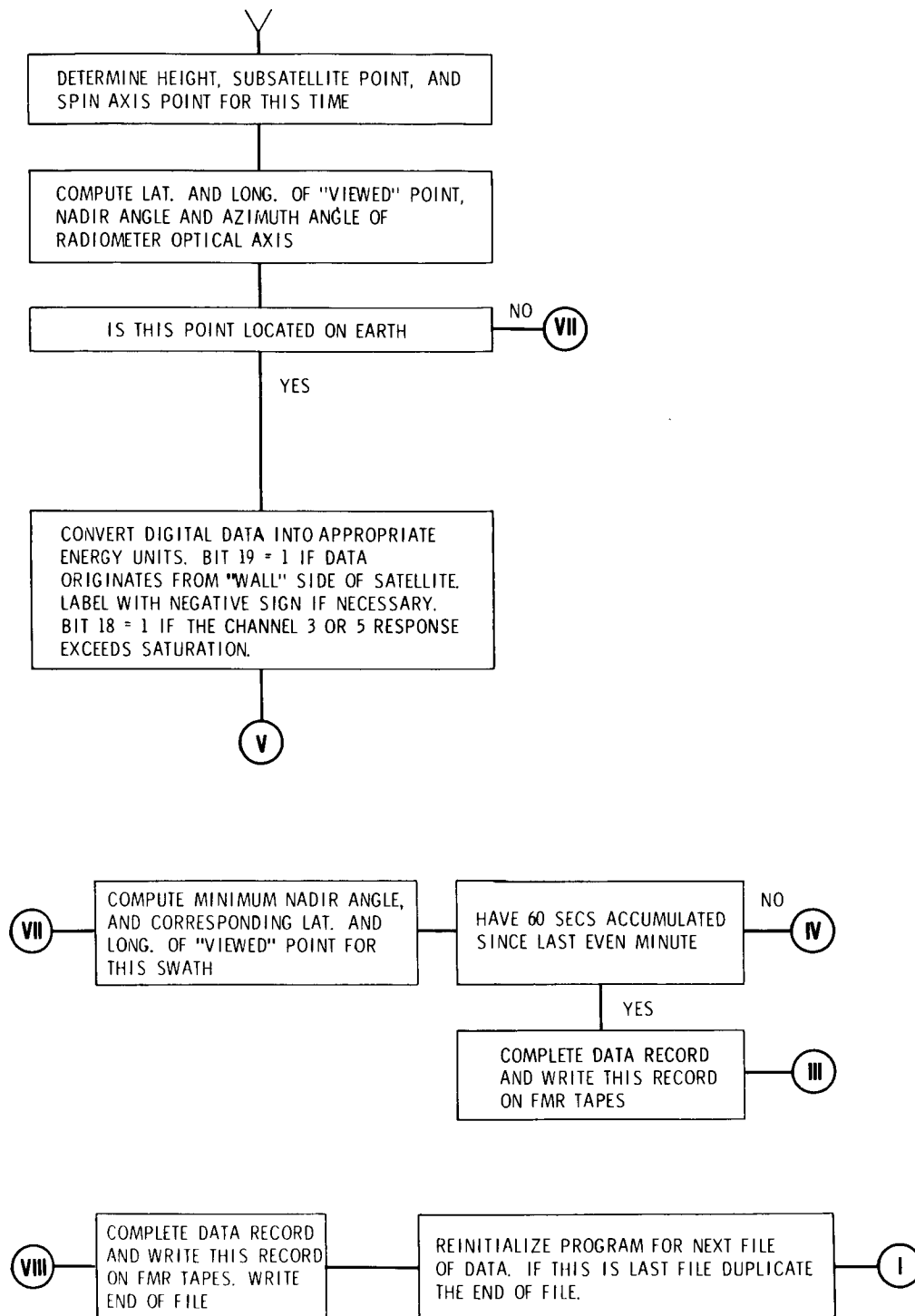


Figure 64—Flow diagram for the IBM 7094 computer program used in reducing the radiation data.









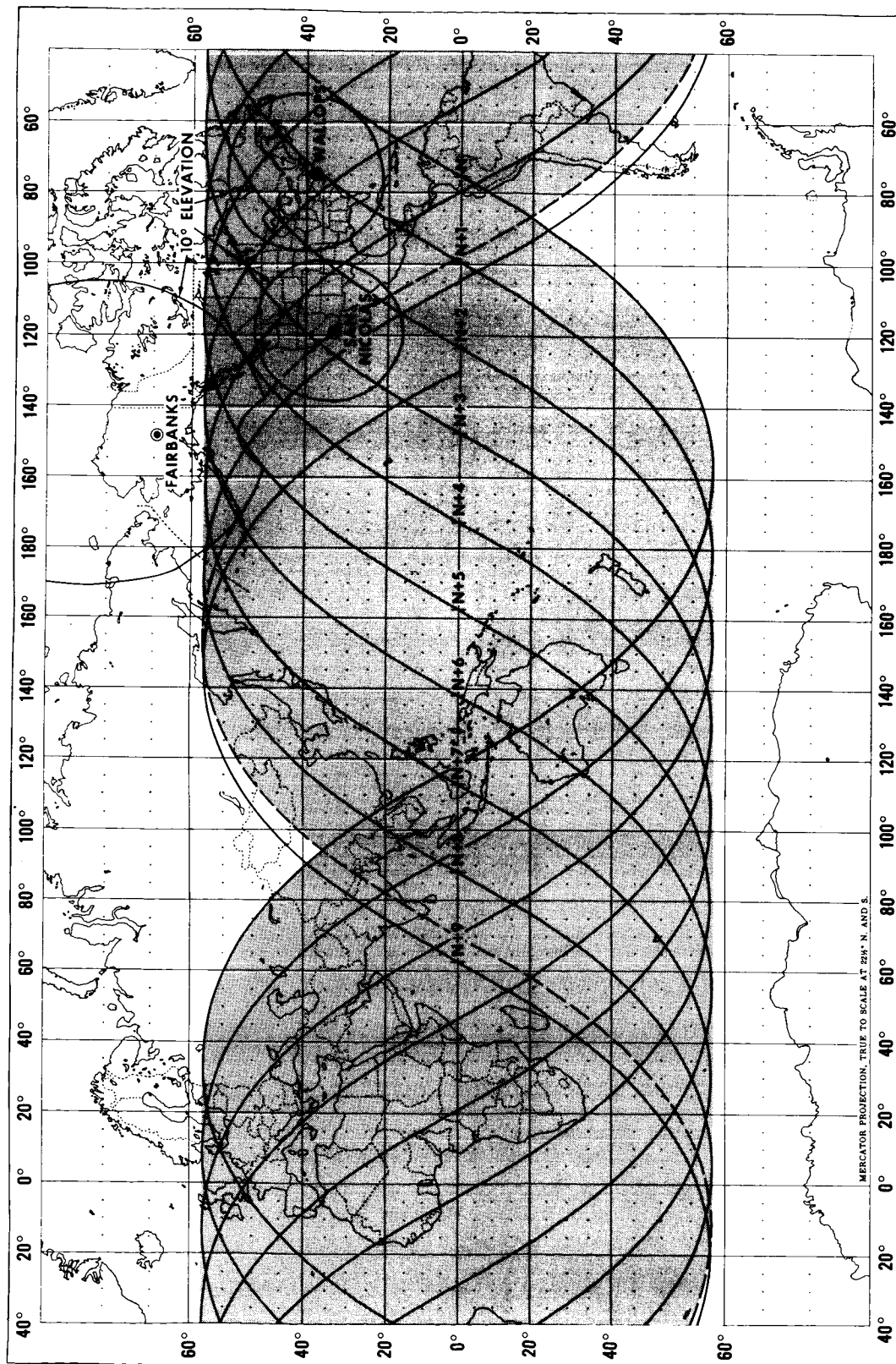


Figure 65—Nominal world-wide radiation data coverage. The shaded area shows the geographical areas from which nearly all radiation data are acquired. The data acquisition circles for a 10° antenna elevation angle at the CDA stations are also shown.

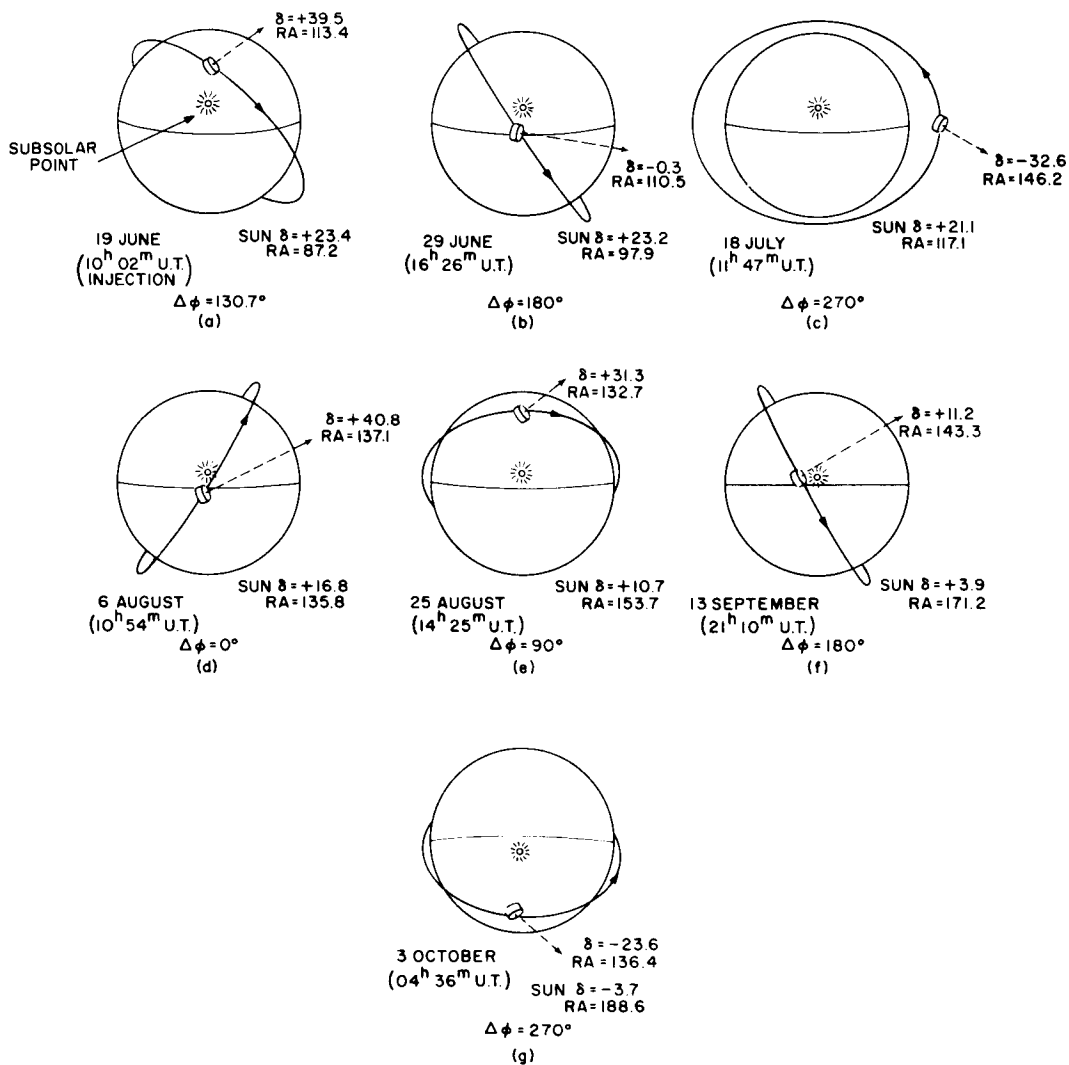


Figure 66—(a, b, c, d, e, f, and g) Heliocentric views of the earth and the precessing TIROS VII orbital plane. The celestial coordinates of the sun and the satellite spin vector are shown for each selected day. The time is given to the nearest minute and corresponds to the given value of  $\Delta\phi$ .

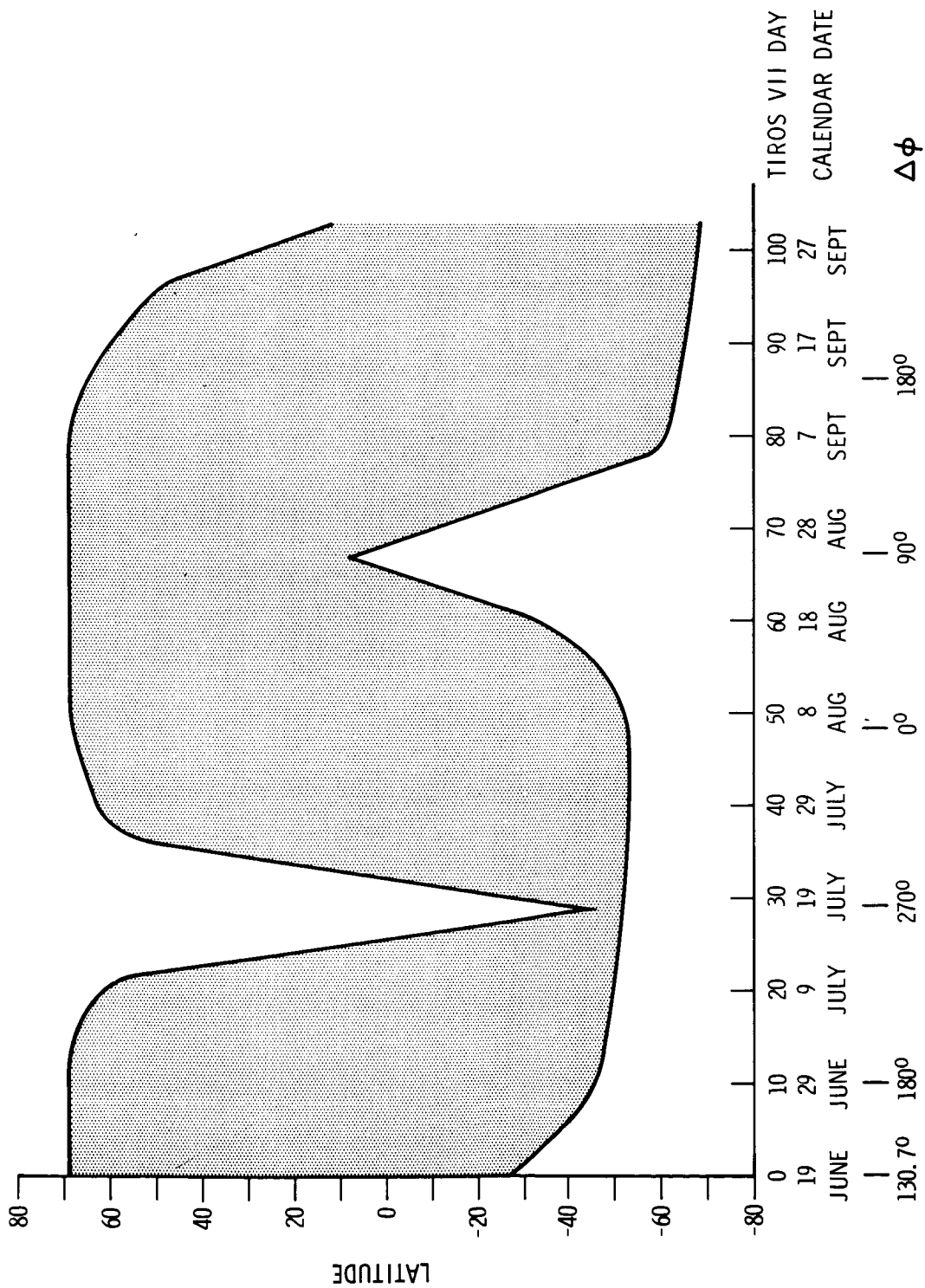


Figure 67—Solar illuminated latitudes for TIROS VII.

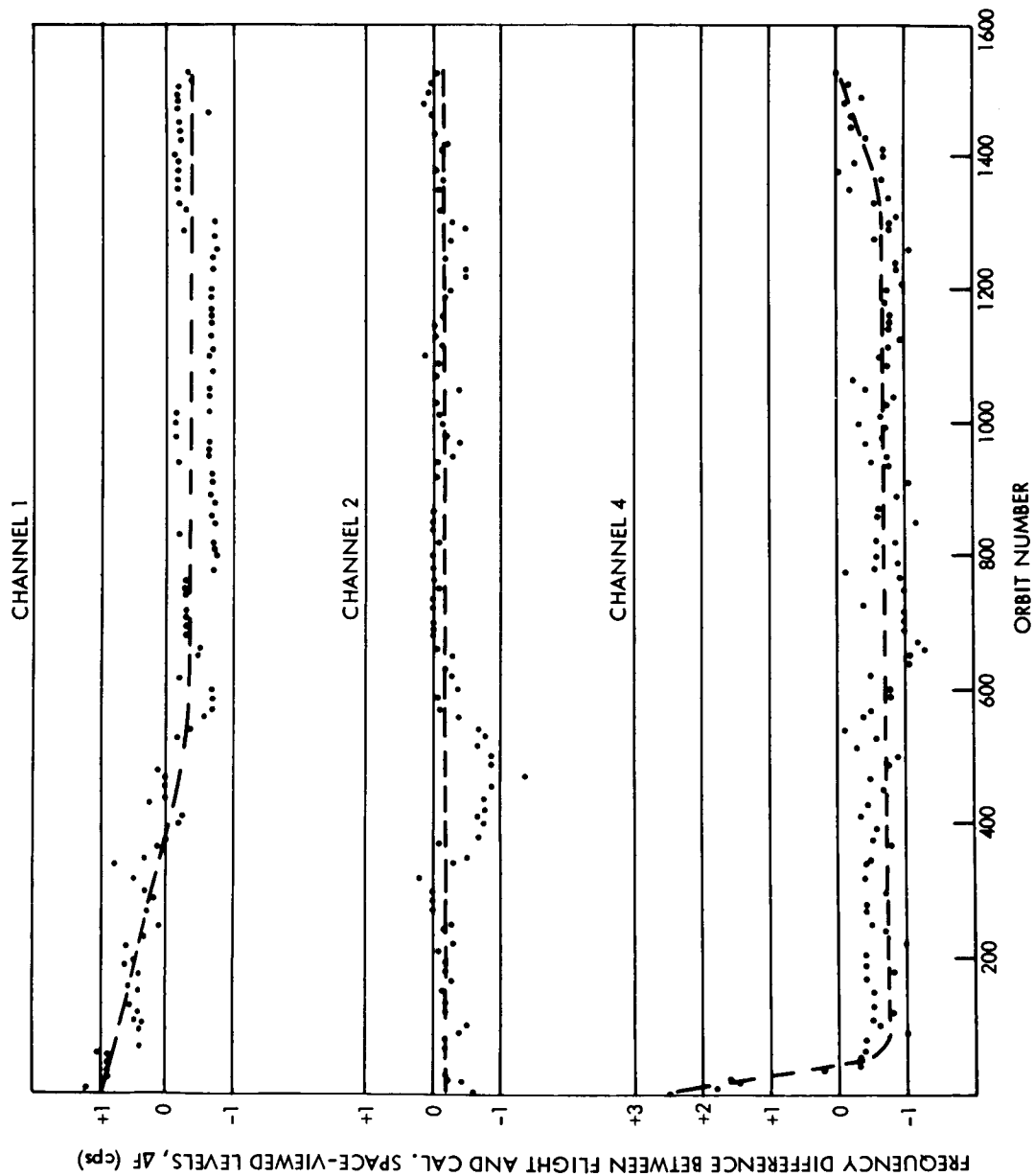


Figure 68a—Frequency difference between flight and calibrated space-viewed levels vs. orbit number for channels 1, 2, and 4.

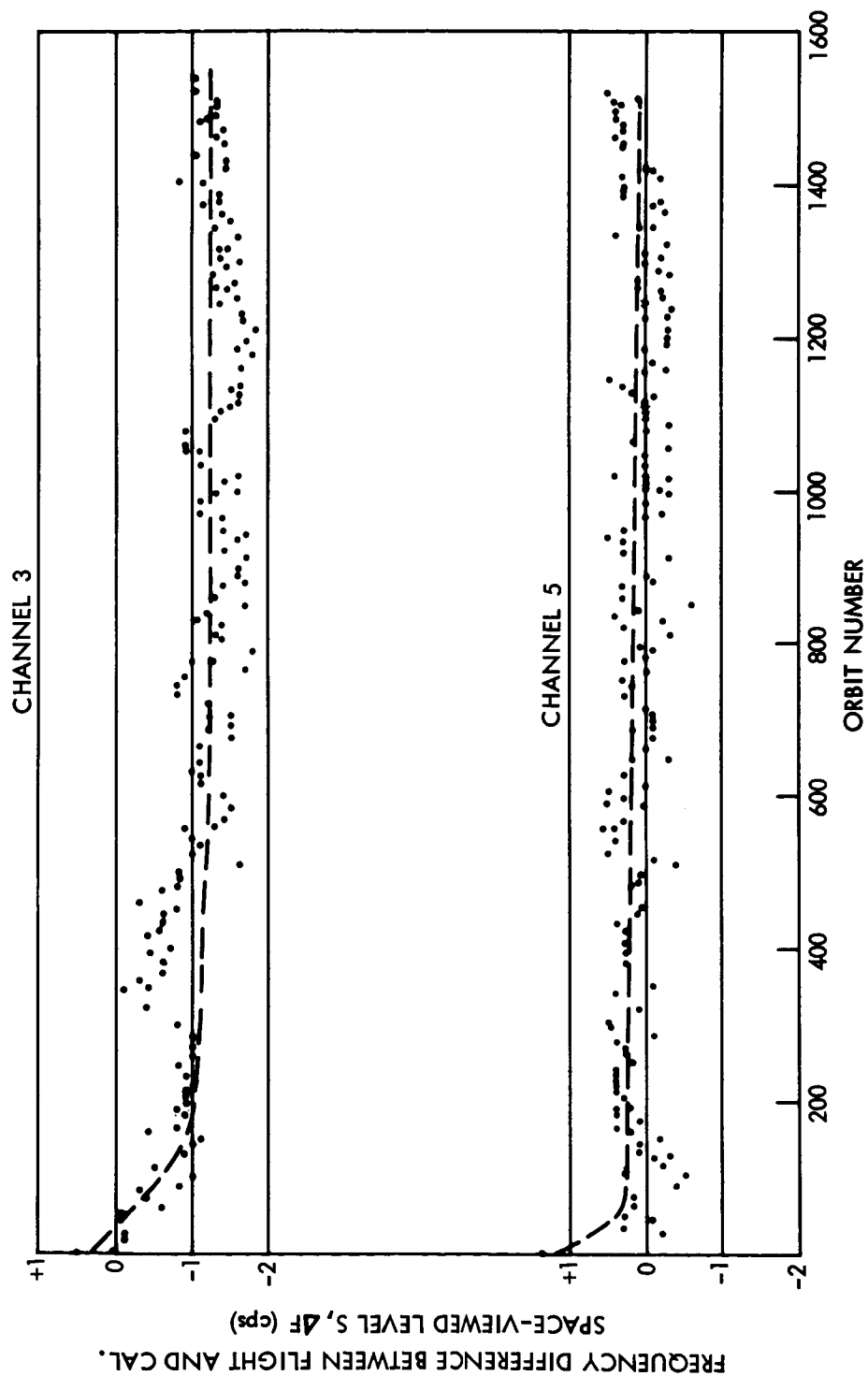
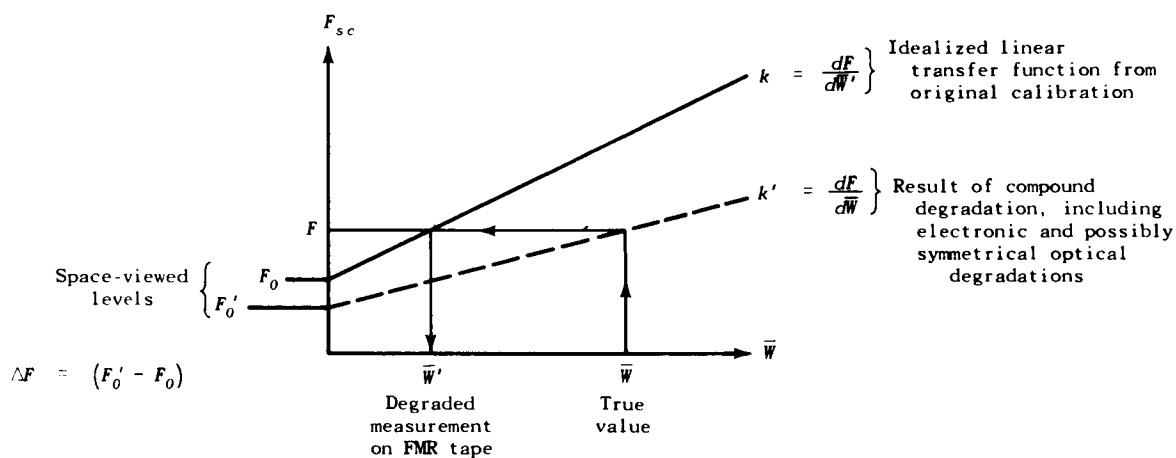


Figure 68b—Frequency difference between flight and calibrated space-viewed levels vs. orbit number for channels 3 and 5.



$$(a) \quad k\bar{W}' = (F - F_0)$$

$$(b) \quad k'\bar{W} = (F - F_0') = (F - F_0) - (F_0' - F_0)$$

$$(c) \quad \bar{W} = \left( \frac{k}{k'} \right) \left[ \bar{W}' - \frac{\Delta F}{k} \right]$$

At orbit  $i$

$$(d) \quad \bar{W} = \kappa^i [\bar{W}' + \rho^i] \text{ where } \kappa^i = \left( \frac{k}{k'} \right)^i \text{ and } \rho^i = \left( \frac{-\Delta F}{k} \right)^i$$

Figure 69—Schematic representation of the compound degradation model, including electronic and possibly symmetrical optical degradations. A true value,  $\bar{W}$ , is recorded as a measurement,  $\bar{W}'$ . Equation (d) converts the degraded measurement to its true value at orbit  $i$ .

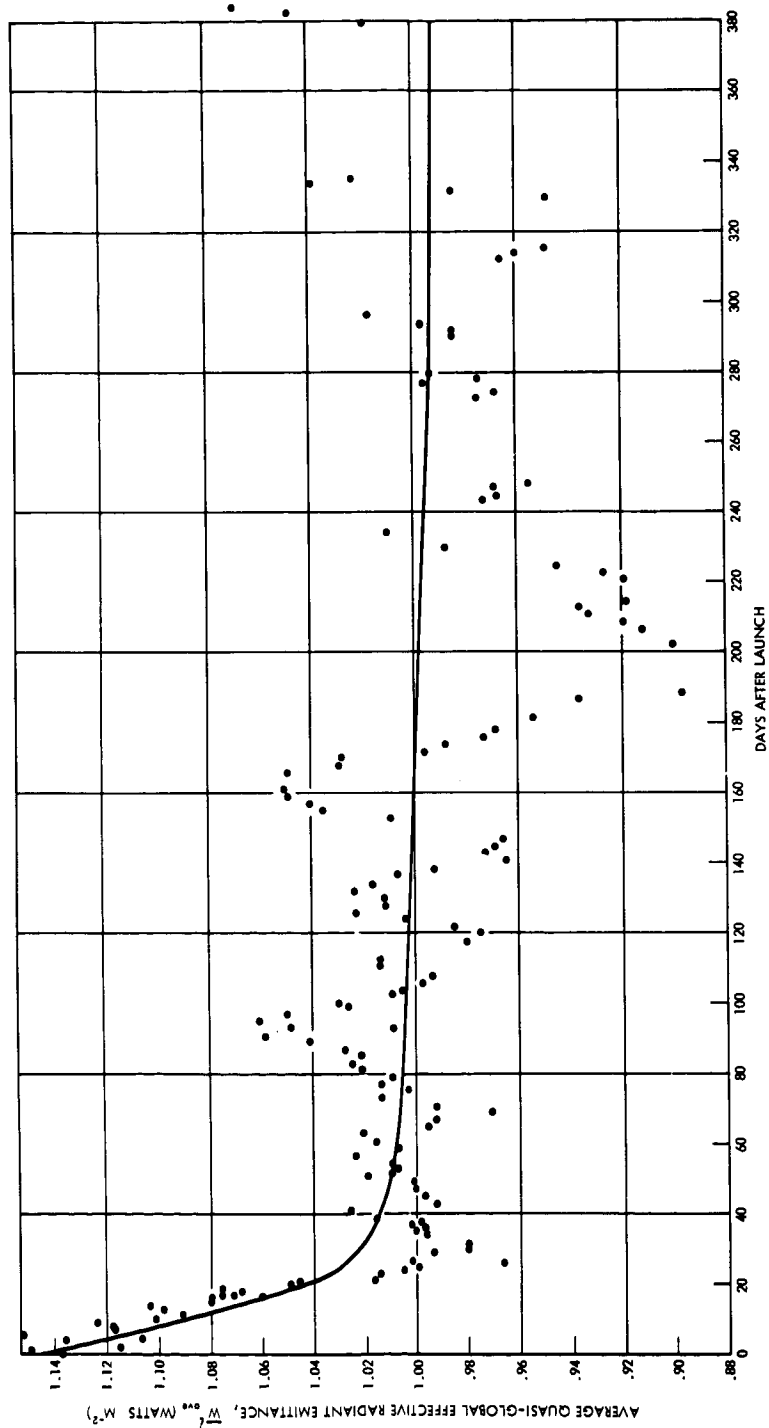


Figure 70—The average quasi-global effective radiant emittance,  $\bar{W}_{ave}^i$ , for channel 1 vs. days after launch.



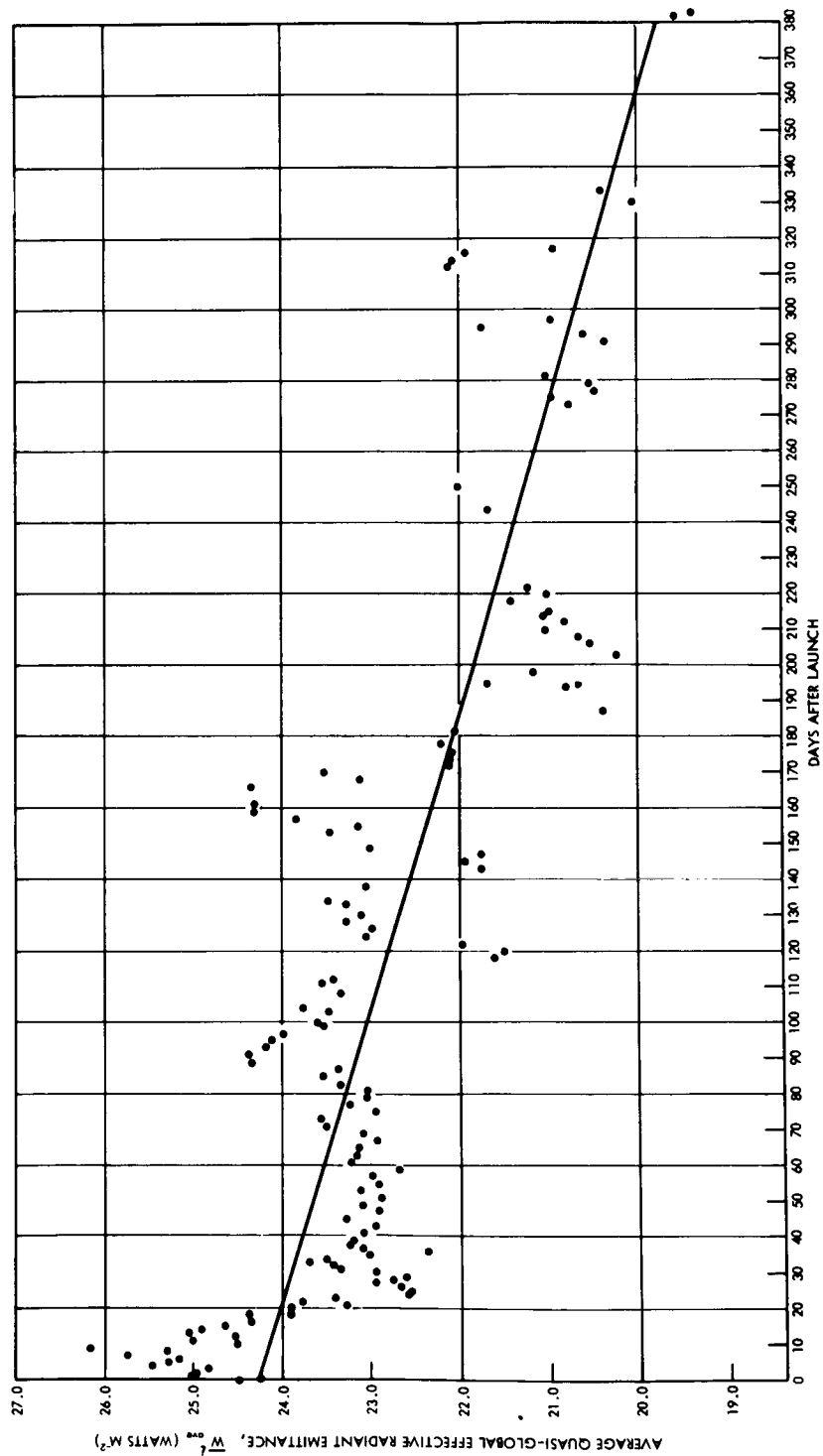


Figure 71—The average quasi-global effective radiant emittance,  $\bar{W}_{avg}^i$ , for channel 2 vs. days after launch.

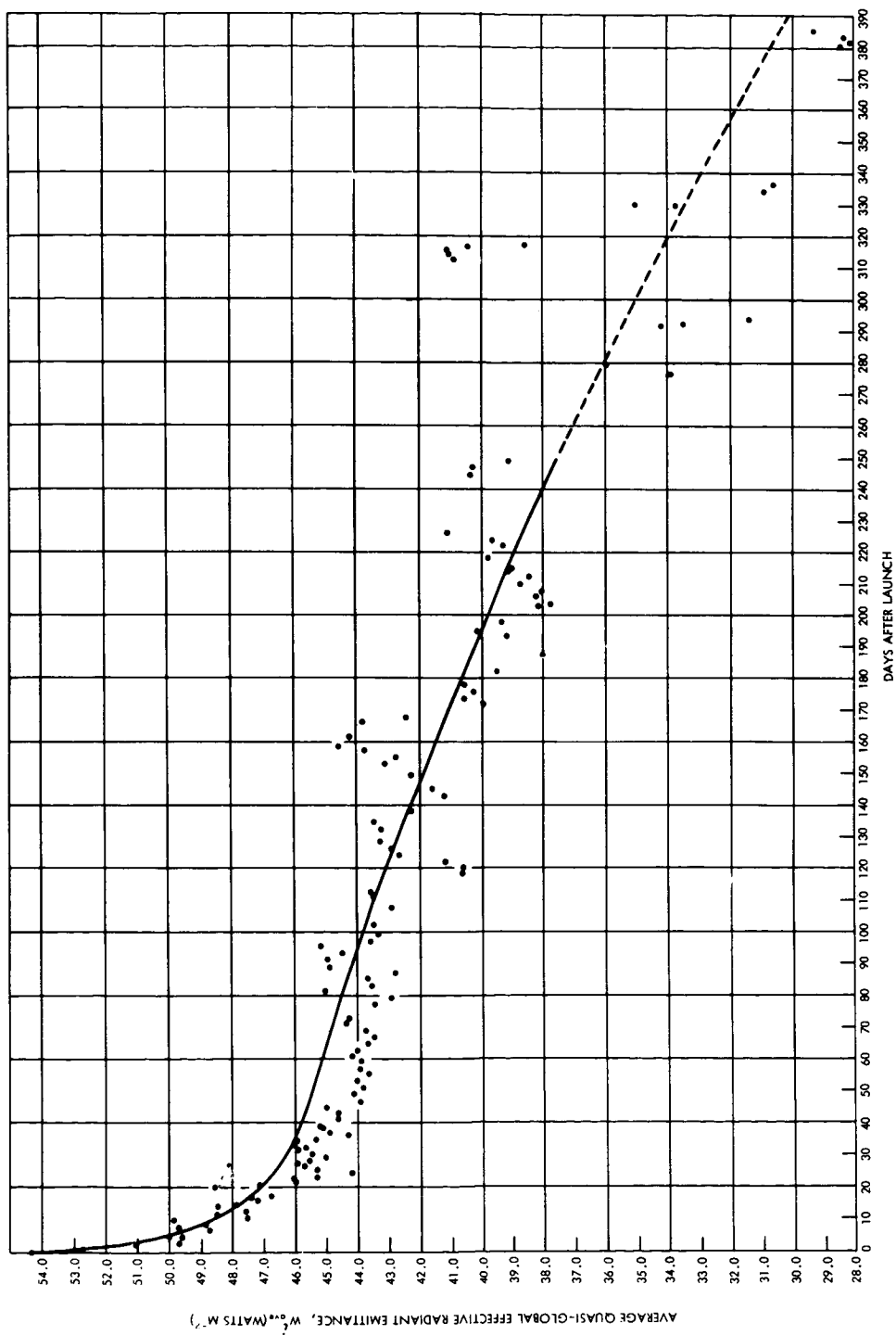


Figure 72—The average quasi-global effective radiant emittance,  $\bar{W}_{avg}$ , for channel 4 vs. days after launch. A dashed line follows day 249 when an erratic "stepped" characteristic was first noticed in the space-viewed portions of the analog presentations of the data.

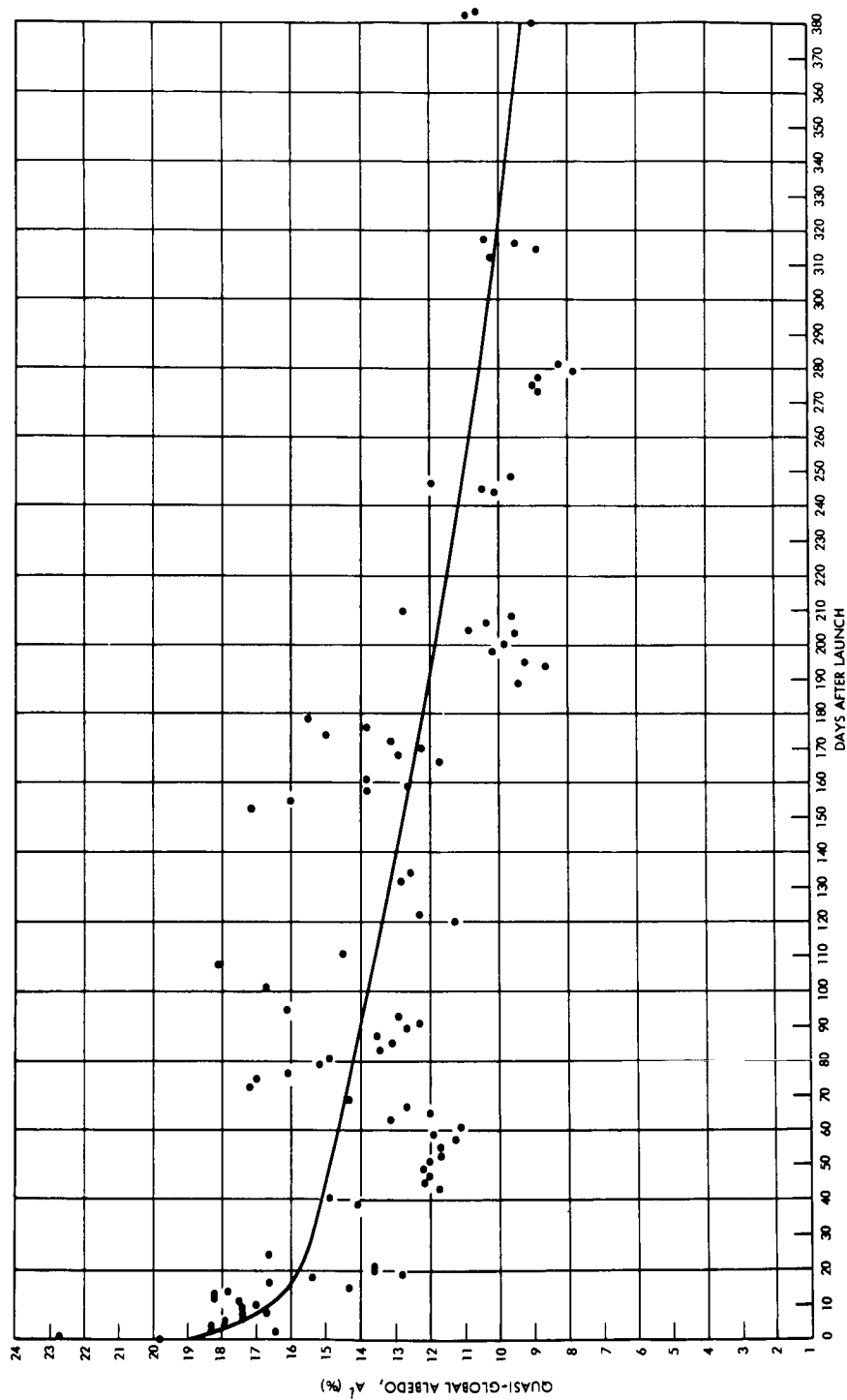


Figure 73—The quasi-global albedo,  $A^1$ , for channel 3 vs. days after launch.

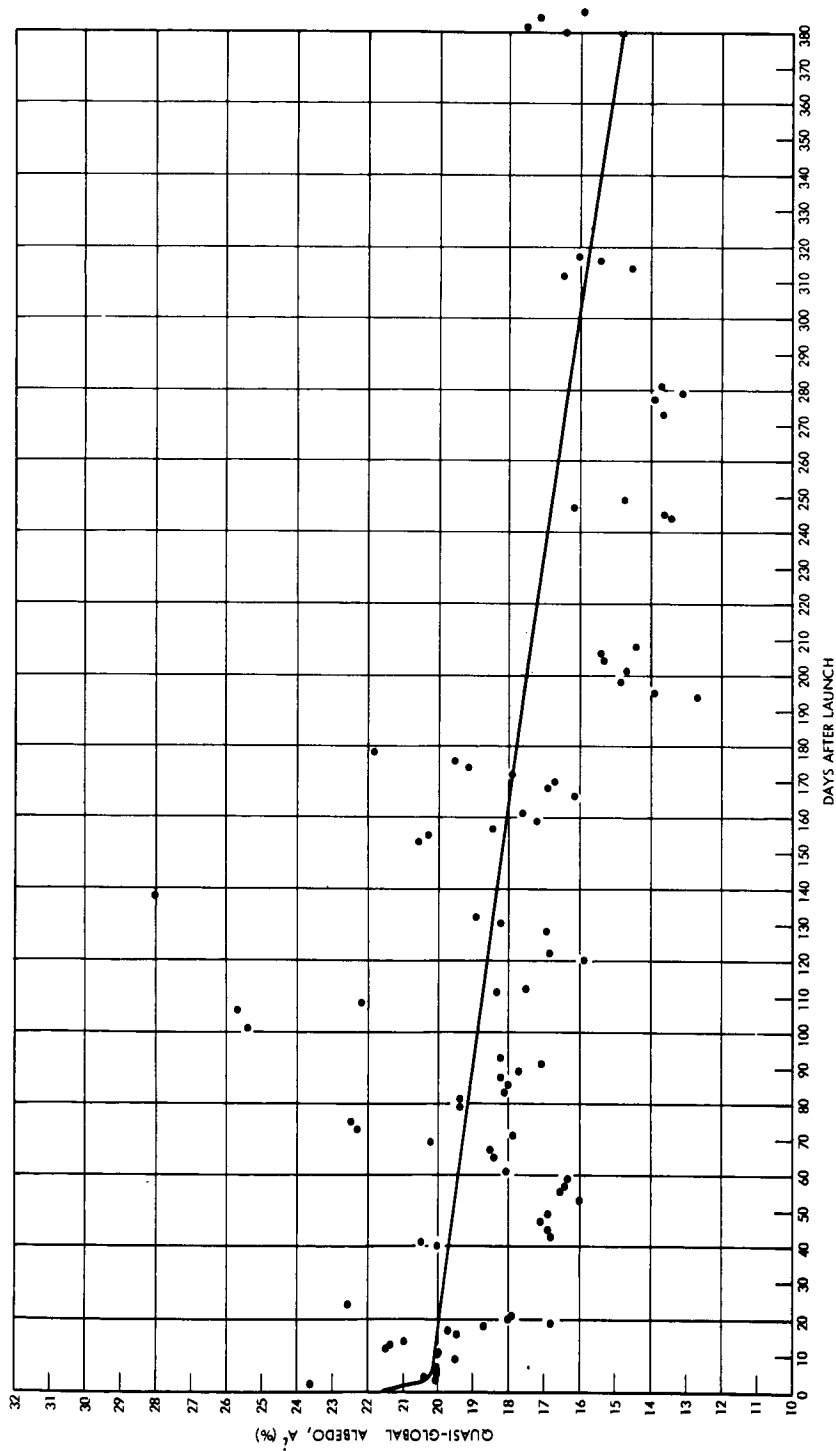


Figure 74—The quasi-global albedo,  $A_g$ , for channel 5 vs. days after launch.

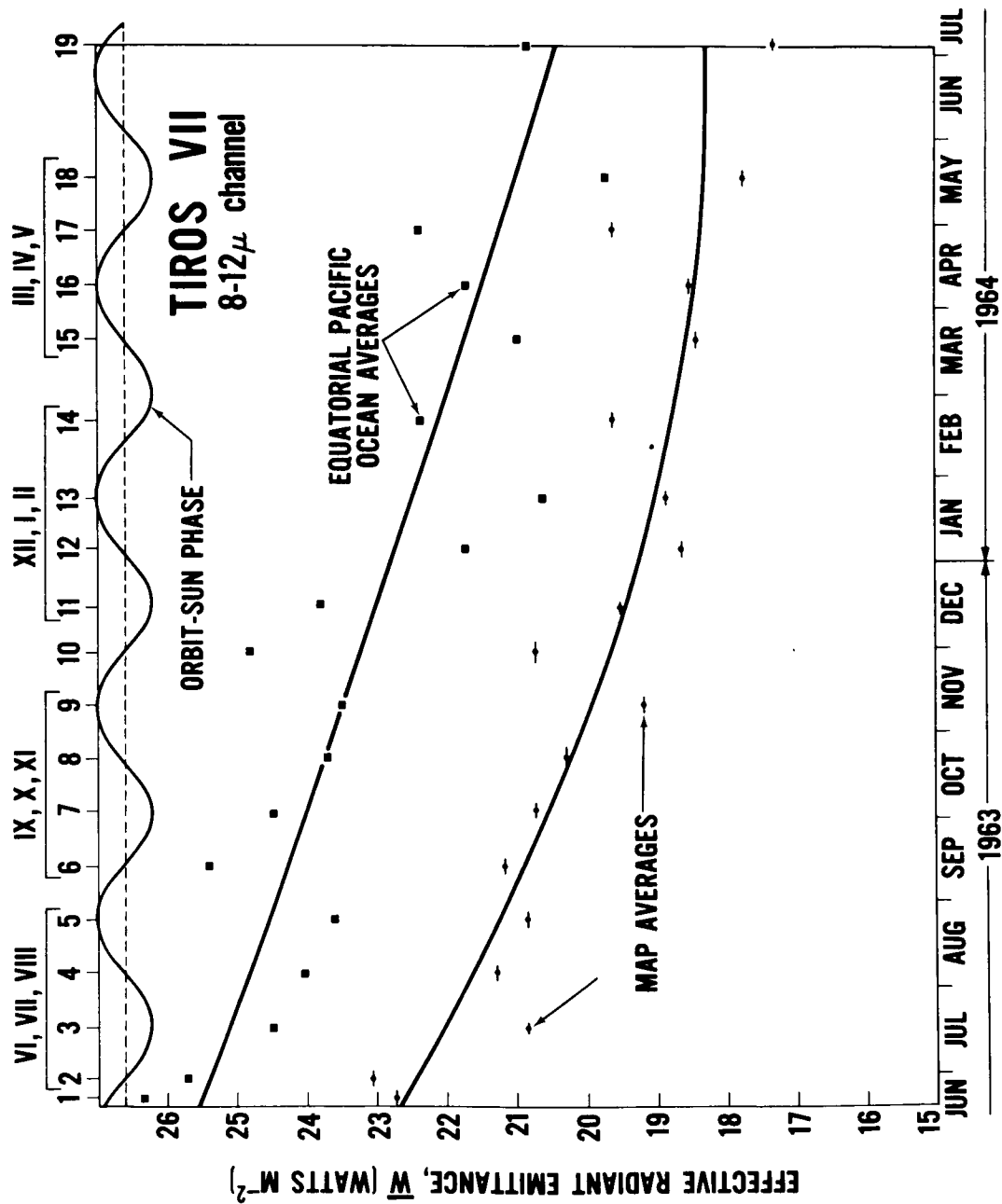


Figure 75—Effective radiant emittance,  $\bar{W}$ , vs. time from over-all map averages and equatorial Pacific Ocean averages over one year indicating a degradation of the instrumental response and a periodic variation with the orbit-sun phase geometry.

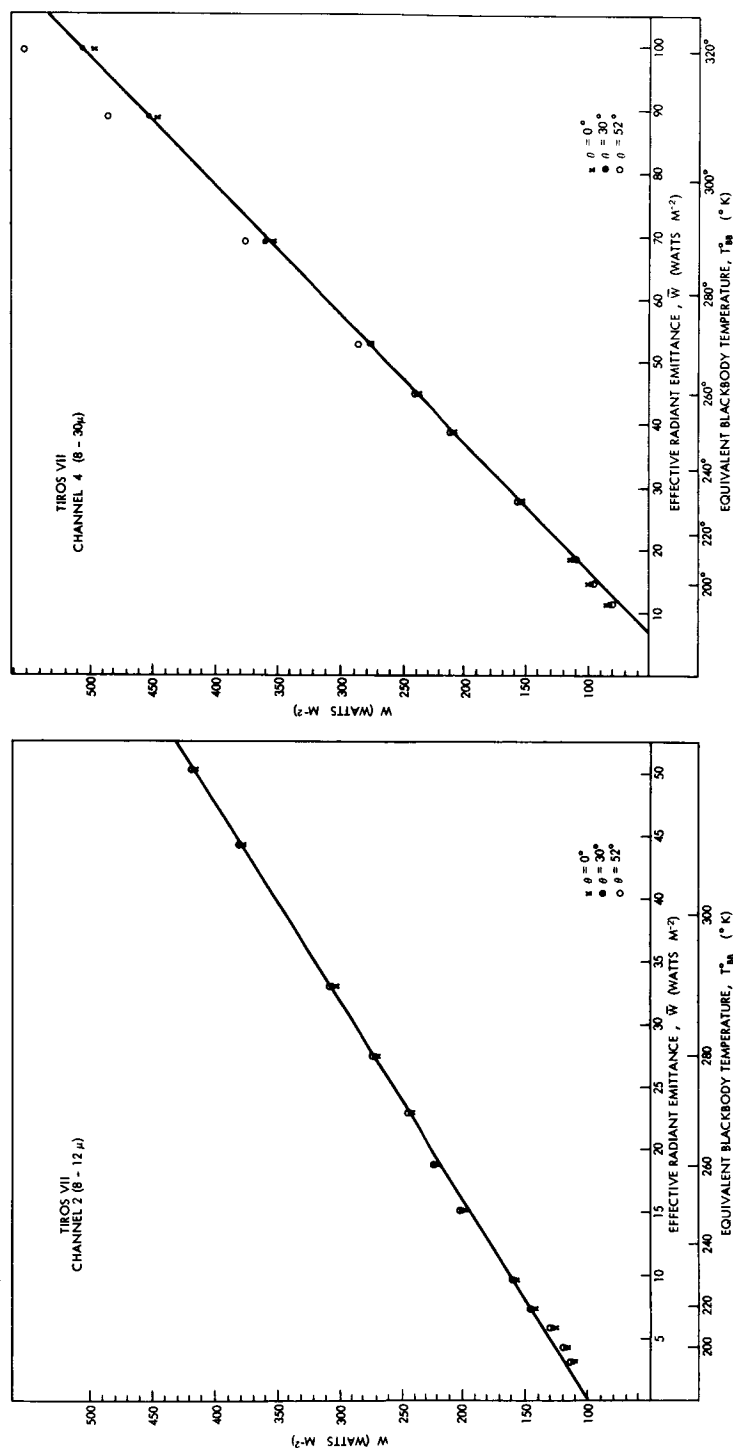


Figure 76—Total radiant emittance,  $\bar{W}$ , plotted as a function of effective radiant emittance to which an undegraded sensor responds,  $\bar{W}$ , for channel 2 (a) and channel 4 (b) at zenith angles of  $0^\circ$ ,  $30^\circ$ , and  $52^\circ$ . The straight line approximations were adopted for further manipulation of the  $\bar{W}$  values printed out by the computer.

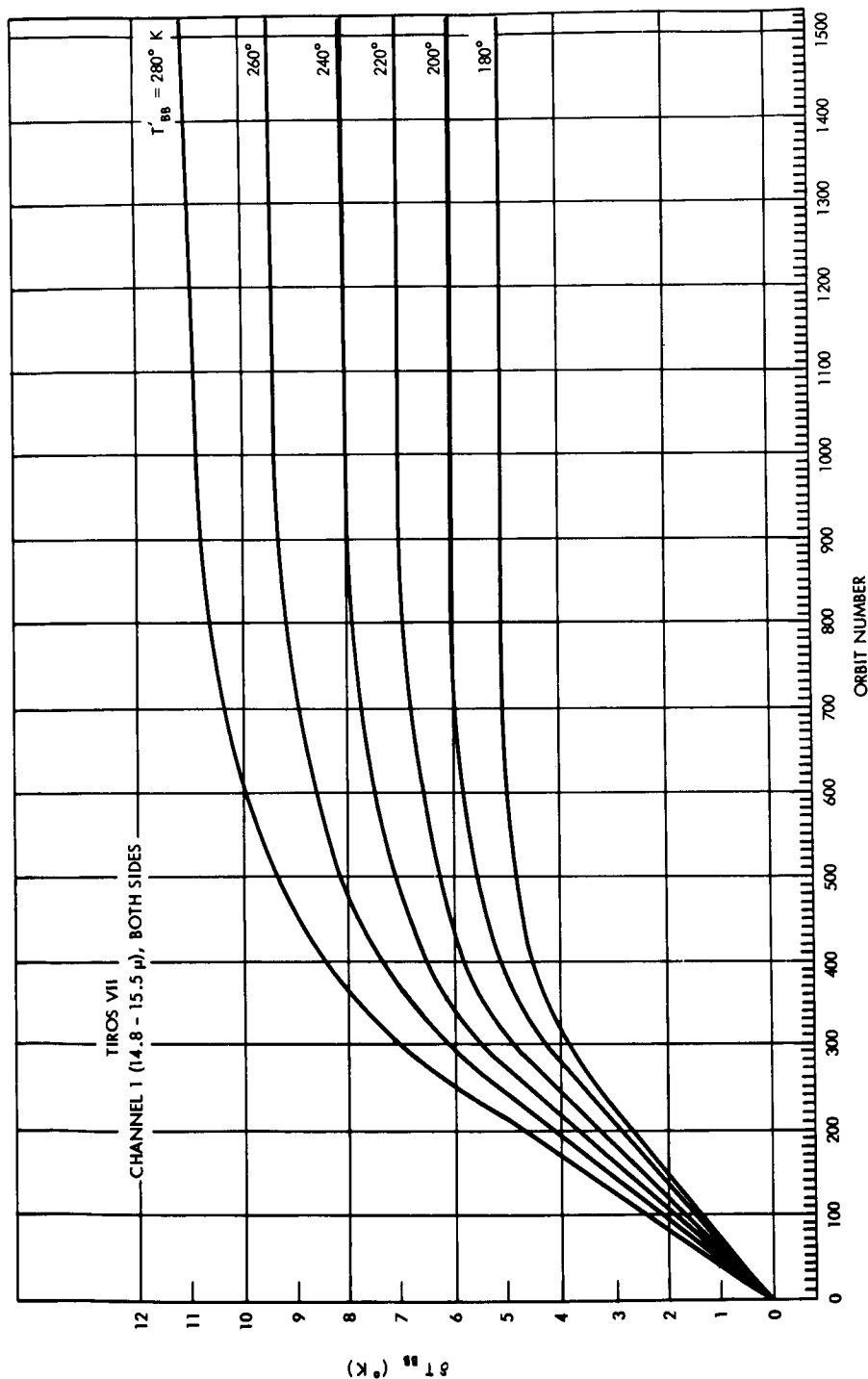


Figure 77—Temperature corrections,  $\delta T_{ss}$ , vs. orbit number, channel 1, both sides. An equivalent blackbody temperature measurement,  $T'_{ss}$ , should be corrected by adding the  $\delta T_{ss}$  value corresponding to the appropriate orbit number. (There is some evidence that, in addition to the nomogram corrections, approximately  $2.5^{\circ} \text{ K}$  should be subtracted from measurements made through the floor and added to measurements made through the wall of channel 1).





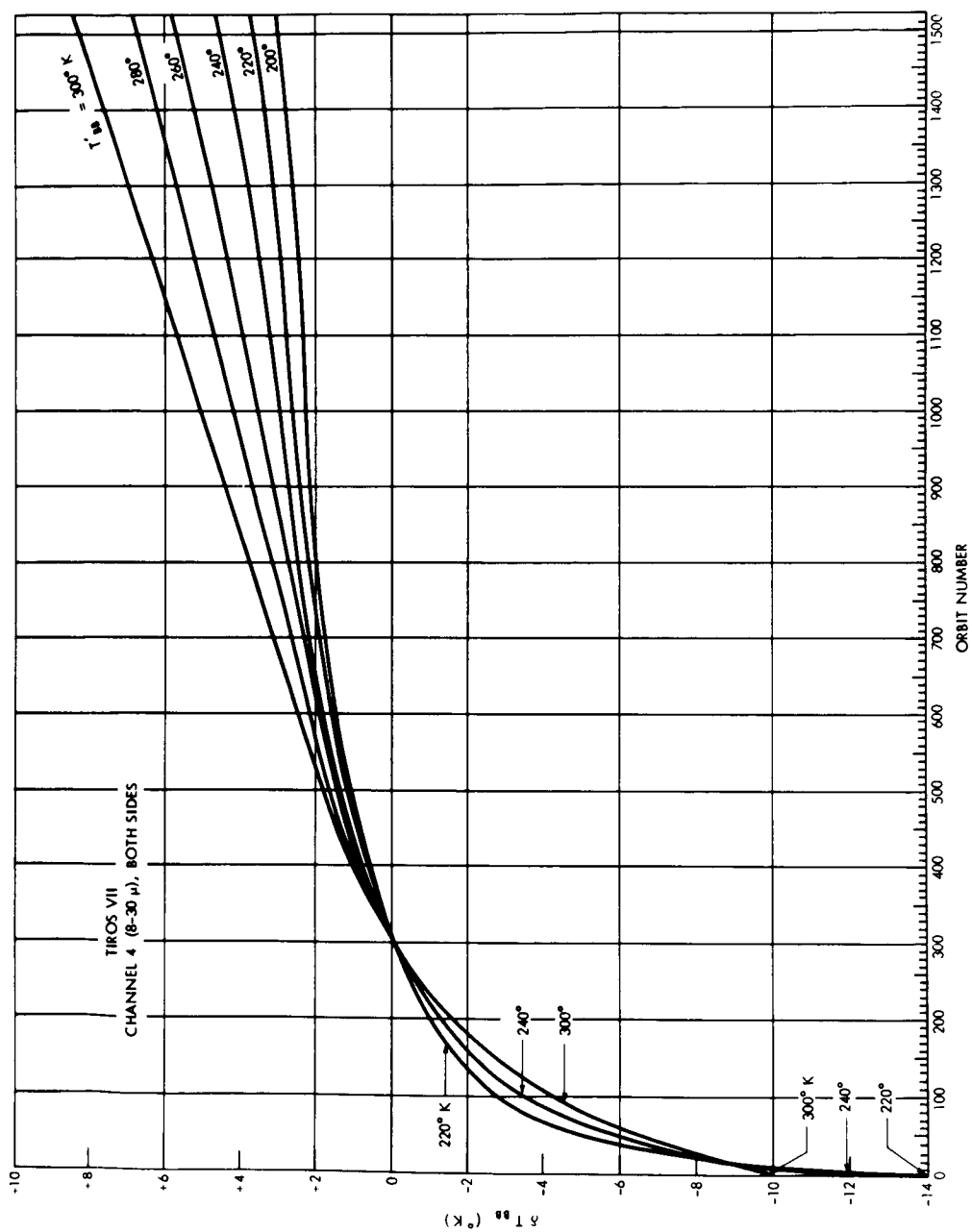


Figure 79—Temperature corrections,  $\delta T_{RR}$ , vs. orbit number, channel 4, both sides. An equivalent blackbody temperature measurement,  $T_{RR}$ , should be corrected by adding algebraically the  $\delta T_{RR}$  value corresponding to the appropriate orbit number.

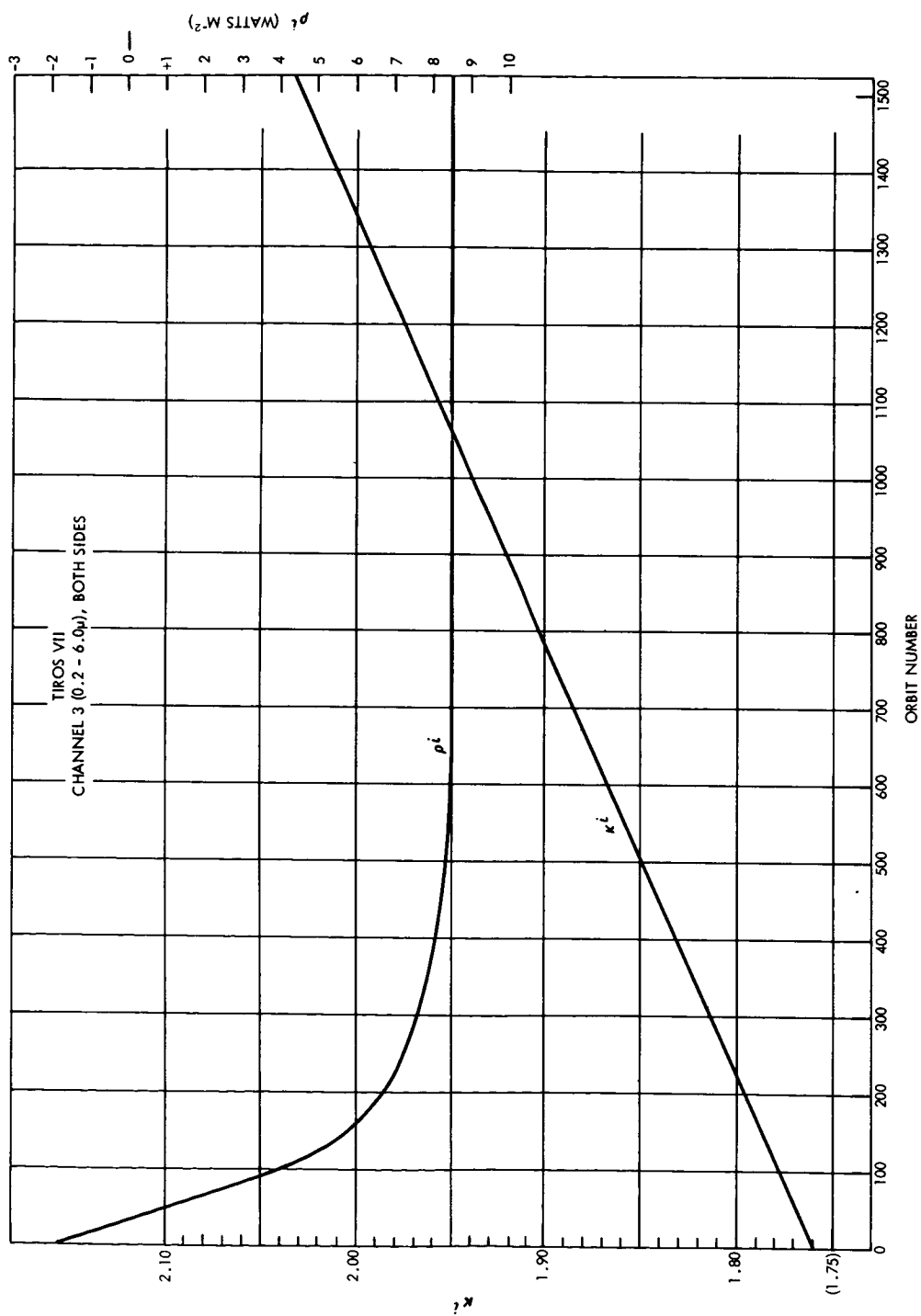


Figure 80—Normalizing parameters  $\kappa_i$  and  $\rho_i$  for channel 3. A measurement,  $\bar{W}$ , should be corrected to yield  $\bar{W} = \kappa_i [\bar{W}' + \rho_i]$ .

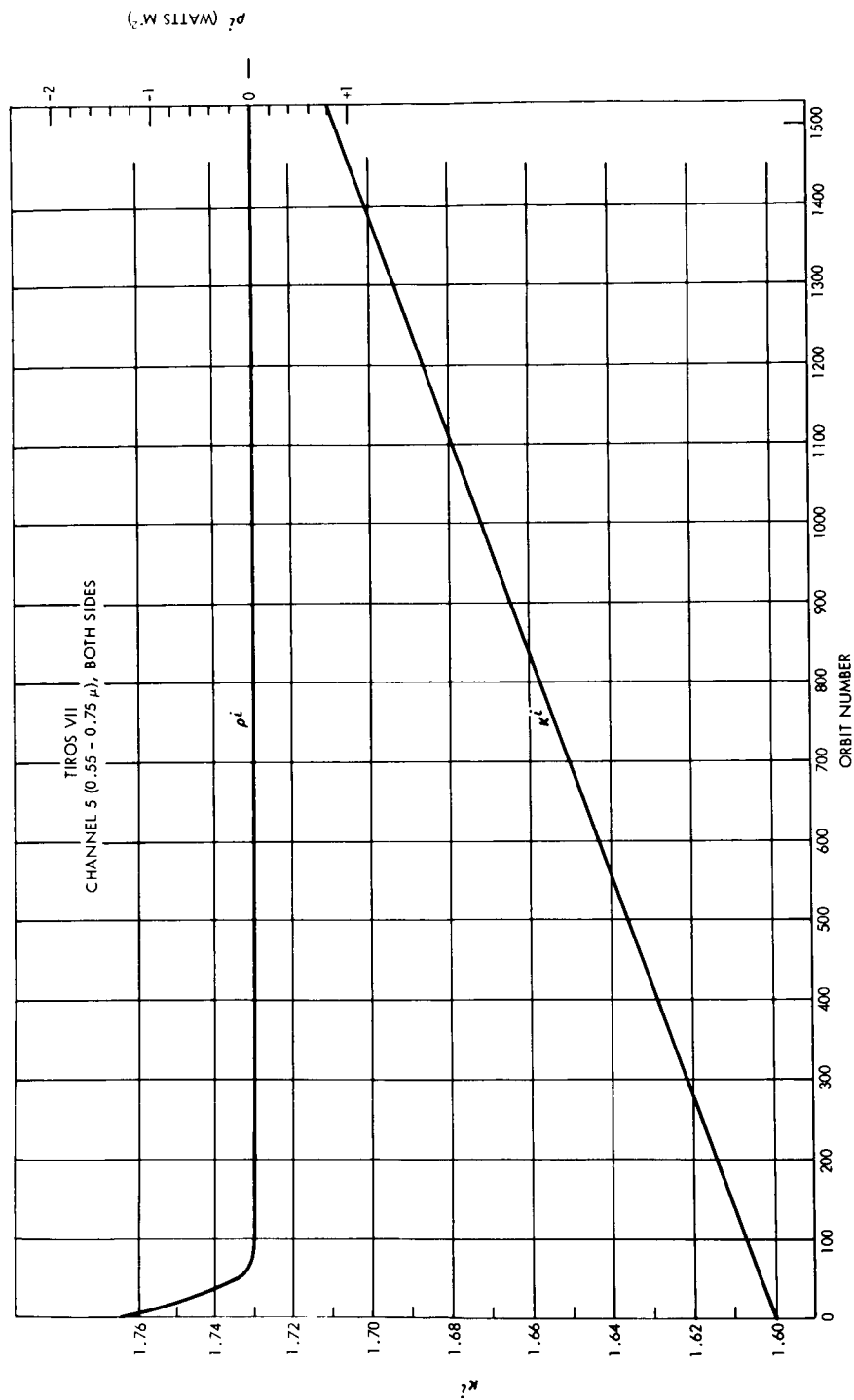


Figure 81—Normalizing parameters  $\kappa_i$  and  $\rho_i$  for channel 5. A measurement,  $W'$ , should be corrected to yield  $W$  by means of the equation  $W = \kappa_i [W' + \rho_i]$ .

## APPENDIX A

### INDEX OF FINAL METEOROLOGICAL RADIATION TAPES

105 FMR tapes, containing data from 576 individual orbits of TIROS VII from launch, June 19, 1963, to September 30, 1963, are tabulated on the following pages. The FMR tapes for this period are numbered from 333 through 437. TIROS II, TIROS III, and TIROS IV radiation data are contained on the first 332 numbered tapes.

The Index is designed to be used in conjunction with the Mercator Projection World Maps in Appendix B and the master subpoint track overlay in the pocket at the rear of this volume. The subpoint track is divided into one minute intervals referred to ascending node time, with the "minus" and "plus" indicators corresponding to "before" and "after" ascending node time, respectively.

The Index is divided into two basic sections. One section contains information concerning the attitude of the satellite and the location of the subpoint track as a function of time for each orbit listed on the FMR tape. The second section of the Index contains information that gives the time for which radiation data are available on the FMR tape for each orbit listed. The nomenclature used in the Index is defined below.

#### INDEX NOMENCLATURE

Heading	Explanation
Orbit No.	The orbit number increases by one at each ascending node, orbit zero being from launch to the first ascending node. The orbit number given in the Index is the "readout" orbit number, i.e., the number of the orbit at the time of "readout" over the acquisition station. The "readout" orbit number applies to all of the data read out at one time, although some were acquired on the previous numbered orbit.

Heading	Explanation
CDA Station	Command and Data Acquisition Station at which the satellite was interrogated. "1" is the Wallops Island, Virginia station, "2" is the San Nicolas Island, California station, and "3" is the Fairbanks, Alaska station.
Satellite Equator Crossing at Orbital Ascending Node (ANO)	
Earth longitude	The longitude on the earth at which the sub-satellite track crossed the equatorial plane going from south to north, measured in degrees from 0° to 180° west (designated by a "minus" sign) and from 180° to 0° east (designated by no sign).
Hours; minutes; seconds; (GMT)	Greenwich Mean Time of the occurrence of ANO in hours, minutes, and seconds.
Calendar date	Date on which the ascending node of the given orbit occurred.
TIROS Day	TIROS Day refers to TIROS VII Day which advances one for each succeeding calendar day after June 19, 1963, the day of launch. Launch day is TIROS VII Day "0."
Spin Vector Attitude	
Declination	Celestial coordinates of declination and right ascension of the satellite spin vector. The tabulated values for each orbit are for the time of ascending node. As these change only slightly throughout one or
Right Ascension	

Heading	Explanation
	bit, the value at the time of ANO is adequate, for most purposes, for the entire orbit. Positive or negative values of declination refer to north or south, respectively.
Minimum Nadir ( $\eta_0$ )	Satellite attitude in a system which has the orbital coordinates chosen as a reference system. $\eta_0$ is the minimum satellite nadir angle during an orbital period and TOT is the time of occurrence of $\eta_0$ . Positive or negative values of $\eta_0$ indicate that the spin axis (in the direction of the TV cameras) is pointed north or south of the subpoint track, respectively, while TOT is given in minutes after ANO.
TOT	
Spin Rate	Rate of rotation of the satellite about its spin axis.
Time Interval of File on FMR Tape	
Begin	The beginning time of the radiation data available on an FMR tape in minutes with respect to (W/R/T) the time of the occurrence of the ANO. Negative or positive values indicate the beginning of the file was before or after ANO, respectively.
End	The ending time of the radiation data available on the FMR tape. This value is given in absolute time (GMT) and in minutes with respect to

Heading	Explanation
	(W/R/T) ANO. The ending time, for all orbits, occurs after the ANO.
Dropouts	The time of the dropouts (where no radiation data are available due to system noise, etc.) is listed in minutes with respect to (W/R/T) the ANO, either minus or plus.
FMR Tape Reel No.	Number of the magnetic tape reel on which the radiation data for an orbit are located.

To illustrate the use of the tabulated material, the entries in the row for orbit No. 277 indicate that when TIROS VII passed within range of the Wallops Island, Virginia, Command and Data Acquisition Station (indicated by a "1") radiation data were telemetered from the satellite. The ascending node (ANO) of orbit 277 was earth longitude 91.36°W (west indicated by the minus sign) when TIROS VII crossed the equatorial plane going from south to north at 03:28:26 GMT on July 8, 1963 which being the nineteenth day after launch day, is "TIROS VII Day 19." The declination and right ascension of the spin vector were 2.4° south of the celestial equator and 103.7° east of the Vernal Equinox. The minimum satellite nadir angle of the orbit was -29.8° and occurred 55.2 minutes after the ANO (or 04:23:38 GMT). The minus sign indicates that the intersection of the spin (camera) axis with the earth (the terrestrial scan-axis primary point) lay south of the subpoint track. The spin rate of the satellite was 48.256 degrees per second. The Index also shows that the FMR tape data began 94.2 minutes before the ascending node (01:54:14 GMT) and ended 10.6 minutes after ascending node, or 03:39:02 GMT. Further, it is seen that a dropout occurs on the tape between -54.4 and -53.4 minutes before

ascending node; i.e., between 02:34:02 and 02:35:02 GMT. Finally, it is seen that these data are recorded on FMR Tape Reel No. 352.

The spin vector celestial coordinates and the satellite spin rate are also presented in graphical form in Figures A1 and A2. Both figures are based on the data presented in the Index.

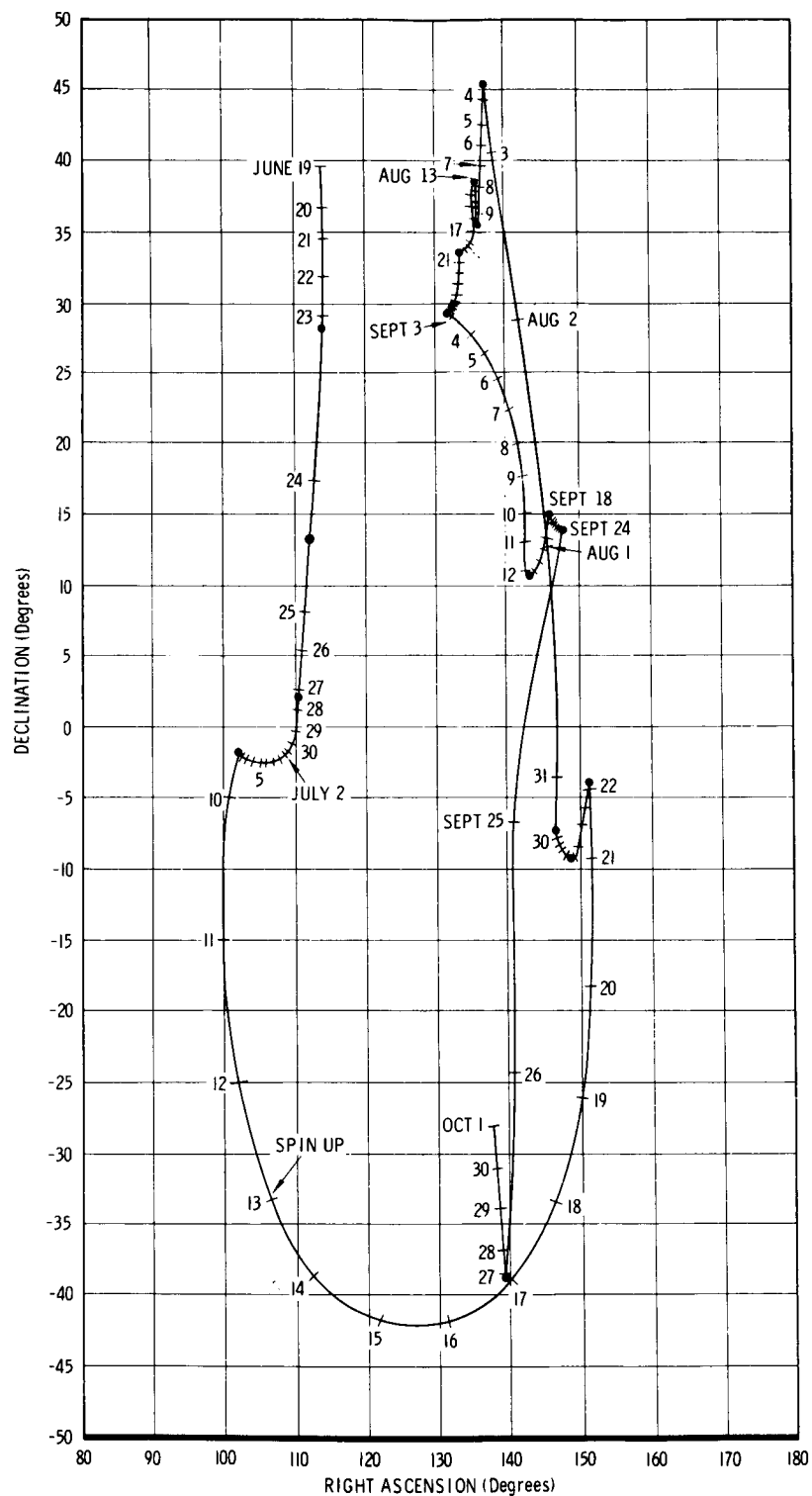


Figure A1—Observed motion of the TIROS VII spin vector on the celestial sphere. Each subdivision represents one day. Positions at 12 GMT each day are indicated.

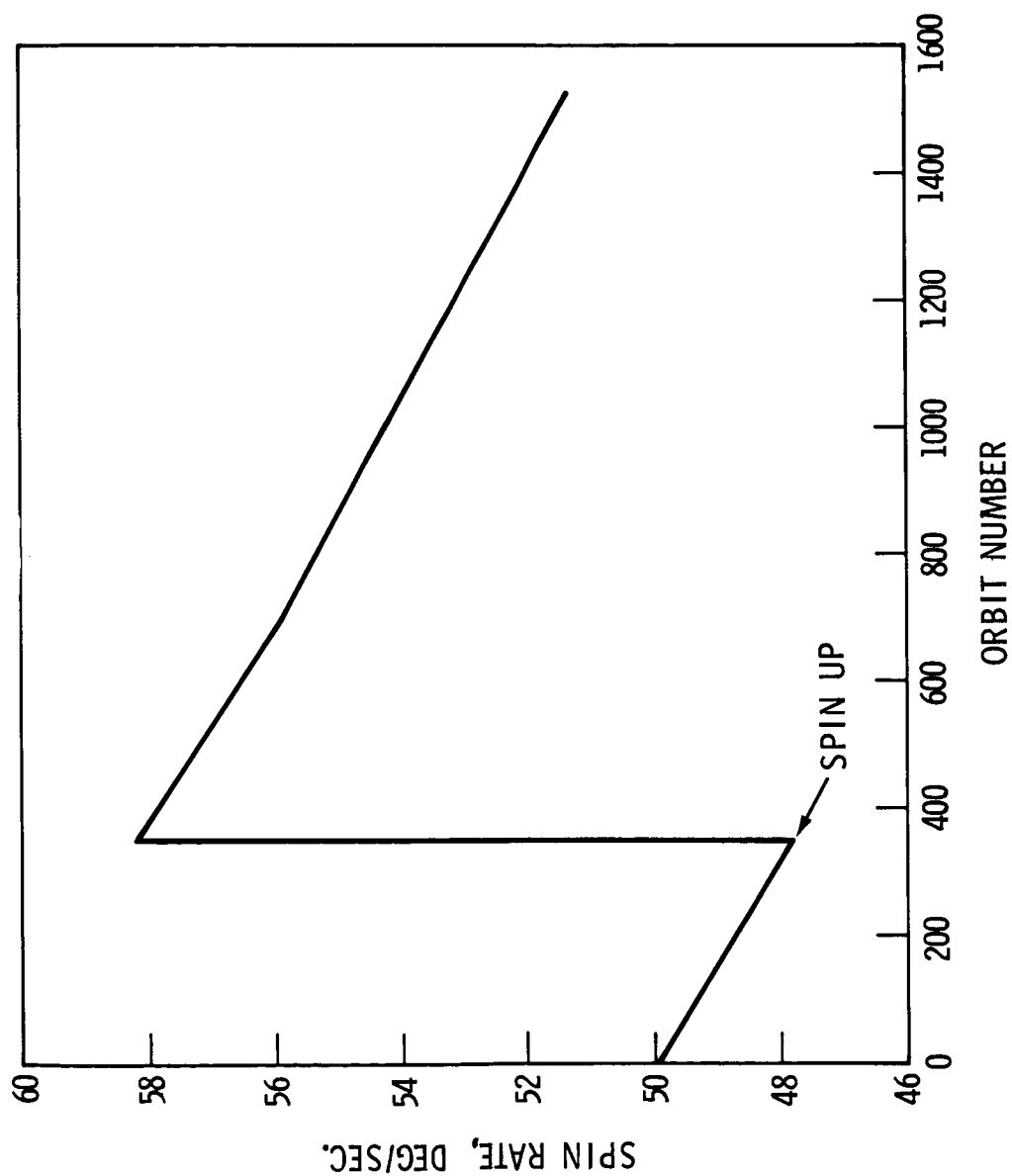


Figure A2—Time history of the TIROS VII spin rate.



ORBIT NO.	CDA STA	READOUT					ORBIT					TIME INTERVAL OF FILE ON FMR TAPE					FMR TAPE REEL NO.	
		SATELLITE ORBITAL		EQUATOR CROSSING AT		SPIN	VECTOR	ATTITUDE		BEGIN	E N D		DROPOUTS, MINUTES					
		EARTH LCNGI (DEG)	HOLDS MINUTES SECONDS (GMT)	CALENDAR DATE	TIROS DAY			DECLI -N- TION (DEG)	RIGHT ASCEN -S- ION (DEG)		MINI -MUM NADIR (DEG)	TOT (MIN. AFTER AND)	SPIN RATE (DEG /SEC)	MINU -TES W/R/T AND	HOURS MINUTES SECONDS (GMT)	MINU -TES W/R/T AND		FROM- TO-
1	1	-121.5	11*23*15	6/19/63	0	39.6	114.0	-5.0	36.6	49.946	-65.7	11*32*3	8.8	333				
2	2	-146.18	13* 0*39	6/19/63	0	39.5	114.0	-5.1	36.6	49.937	-74.6	13*11*3	10.4	333				
4	1	164.46	16*15*29	6/19/63	0	39.2	114.0	-5.2	36.7	49.918	-25.6	16*45*33	30.1	333				
5	1	139.79	17*52*53	6/19/63	0	39.1	114.0	-5.3	36.8	49.939	-56.6	18*28*3	35.2	333				
6	2	115.12	19*30*19	6/19/63	0	39.0	114.0	-5.4	36.8	49.900	-31.6	20* 3*3	32.8	333				
7	2	95.44	21* 7*42	6/19/63	0	38.8	114.1	-5.5	36.9	49.891	-59.2	21*42*33	34.9	333				
14	1	-82.26	8*29*35	6/20/63	1	37.4	114.4	-6.1	37.5	49.831	-96.6	8*38*3	8.5	334				
19	1	154.36	16*36*38	6/20/63	1	36.7	114.2	-6.3	37.8	49.790	-63.6	17* 8*3	31.4	334				
20	1	129.69	18*14* 2	6/20/63	1	36.6	114.2	-6.4	37.9	49.782	13.2	18*51*3	37.0	334				
29	1	-92.36	8*50*44	6/21/63	2	34.8	114.5	-7.1	38.6	49.715	-95.2	9* 0*33	9.8	335				
30	1	-117.43	10*28* 9	6/21/63	2	34.7	114.4	-7.2	38.7	49.708	2.0	10*43*33	15.4	335				
33	1	168.94	15*20*22	6/21/63	2	34.2	114.2	-7.3	38.8	49.687	-22.5	15*50*3	29.7	335				
34	1	144.27	16*57*47	6/21/63	2	34.1	114.2	-7.4	38.8	49.681	-62.0	17*34*24	36.6	335				
35	1	119.59	18*35*12	6/21/63	2	34.0	114.2	-7.5	38.9	49.674	-55.2	19*11*53	36.7	335				
43	1	-77.79	7*34*29	6/22/63	3	32.4	114.4	-8.2	39.5	49.622	-96.7	7*42*33	8.1	336				
48	1	158.84	15*41*32	6/22/63	3	31.6	114.0	-8.5	39.9	49.591	-72.3	16*11*33	30.0	336				
49	1	134.17	17*18*56	6/22/63	3	31.5	114.0	-8.5	39.9	49.585	-60.9	17*53*3	34.1	336				
50	2	100.49	18*56*21	6/22/63	3	31.3	114.0	-8.6	40.0	49.579	-52.8	19*28*3	31.7	336				
51	2	34.82	20*33*45	6/22/63	3	31.2	114.1	-8.7	40.0	49.573	-59.9	21* 9*3	35.3	336				
58	1	-87.89	7*55*38	6/23/63	4	29.8	114.1	-9.4	40.6	49.533	-96.6	8* 4*3	8.4	337				
59	1	-112.56	9*33* 2	6/23/63	4	29.6	114.0	-9.5	40.7	49.527	-49.2	9*46*3	13.0	337				
61	2	-161.90	12*47*52	6/23/63	4	29.3	113.9	-9.6	40.7	49.516	-82.9	12*59*33	11.7	337				
62	1	173.41	14*25*16	6/23/63	4	29.2	113.8	-9.6	40.8	49.510	-76.2	14*54*3	28.8	337				
63	1	148.74	16* 2*41	6/23/63	4	29.1	113.8	-9.7	40.9	49.505	-63.1	16*35*33	32.9	337				
65	2	99.39	19*17*30	6/23/63	4	27.5	114.0	-9.8	41.1	49.494	-69.8	19*53*3	35.6	337				
73	1	-97.90	9*16*47	6/24/63	5	17.6	113.9	-6.6	43.7	49.451	-93.9	8*28*3	11.3	338				

ORBIT NO.	CDA STA	READOUT										ORBIT										TIME INTERVAL OF FILE ON FMR TAPE					FMR TAPE REEL NO.
		SATELLITE ORBITAL		EQUATOR CROSSING AT		SPIN		VECTOR		ATTITUDE		SPIN RATE (DEG /SEC)	BEGIN	E N D		DROPOUTS, MINUTES											
		EARTH LONGI -TUD (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TIROS DAY	DECLI -N- (DEG)	RIGHT ASCEN -SION (DEG)	MINI -MUM NADIR (DEG)	TOT (MIN. AFTER AND)	HOURS MINUTES (GMT)	MINU -TES W/R/T AND			FROM-	TO-												
74	1	-122.67	9*54*11	6/24/63	5	16.5	113.5	-6.0	44.0	49.446	-80.7	10* 8* 3	13.9					338									
75	2	-147.34	11*31*36	6/24/63	5	15.5	113.1	-5.3	44.2	49.443	-77.7	11*41* 3	9.5					338									
77	1	163.30	14*46*25	6/24/63	5	13.7	112.3	-4.0	44.6	49.426	-74.6	15*17* 3	30.6					338									
78	1	138.63	16*23*50	6/24/63	5	12.9	112.0	-3.5	44.8	49.418	-7.0	16*59* 3	35.2					338									
97	1	-83.42	7* 0*31	6/25/63	6	8.6	111.9	-2.4	45.2	49.348	-95.9	7* 9* 3	8.5					339									
88	1	-108.09	8*37*56	6/25/63	6	8.4	111.8	-2.5	45.3	49.341	-81.0	8*48* 3	10.1					339									
89	2	-132.77	10*15*21	6/25/63	6	8.3	111.7	-2.6	45.4	49.333	-81.8	10*22* 3	6.7					339									
90	2	-157.44	11*52*45	6/25/63	6	8.1	111.7	-2.6	45.4	49.326	-85.2	12* 3* 3	10.3					339									
92	1	153.20	15* 7*34	6/25/63	6	7.8	111.5	-2.8	45.5	49.311	-74.3	15*38* 3	30.5					339									
93	1	128.53	16*44*59	6/25/63	6	7.6	111.5	-2.9	45.6	49.304	-40.6	17*20* 3	35.1					339									
94	2	103.86	19*22*24	6/25/63	6	7.4	111.5	-3.0	45.6	49.297	-56.3	18*58* 3	35.7					339									
95	2	79.18	19*59*48	6/25/63	6	7.2	111.5	-3.1	46.7	49.290	-56.3	20*36* 3	36.3					339									
102	1	-93.52	7*21*40	6/26/63	7	5.7	111.5	-3.8	47.3	49.257	-95.8	7*31* 3	9.4					340									
103	1	-118.19	8*59* 5	6/26/63	7	5.6	111.4	-3.9	47.4	49.250	-82.0	9*13* 3	14.0					340									
104	2	-142.87	10*36*30	6/26/63	7	5.4	111.3	-3.9	47.5	49.246	-78.0	10*47* 3	10.6					340									
106	1	167.78	13*51*19	6/26/63	7	5.1	111.2	-4.1	47.6	49.235	-71.4	14*21* 3	29.7					340									
107	1	143.10	15*28*44	6/26/63	7	4.9	111.1	-4.1	47.7	49.227	25.3	16* 2* 3	33.3					340									
108	2	118.43	17* 6* 8	6/26/63	7	4.8	111.1	-4.2	47.8	49.222	-59.2	17*38* 3	31.9					340									
109	2	93.76	18*43*33	6/26/63	7	4.6	111.1	-4.3	47.8	49.217	-60.3	19*21*33	38.0					340									
117	1	-103.62	7*42*50	6/27/63	8	2.9	111.0	-5.2	48.5	49.170	-94.1	7*54* 3	11.2					341									
119	2	-152.97	10*57*39	6/27/63	8	2.6	110.8	-5.3	48.6	49.158	-93.5	11* 8* 3	10.4					341									
121	1	157.68	14*12*28	6/27/63	8	2.3	110.7	-5.4	48.7	49.145	-73.8	14*43*43	31.3					341									
122	1	133.00	15*49*53	6/27/63	8	2.1	110.6	-5.5	48.8	49.140	-60.5	16*26*24	36.5					341									
123	2	108.33	17*27*17	6/27/63	8	2.0	110.6	-5.6	48.8	49.135	-55.5	18* 2*33	35.3					341									
124	2	83.66	19* 4*42	6/27/63	8	1.9	110.6	-5.7	48.9	49.130	-55.8	19*41* 3	36.4					341									
131	1	-89.05	6*26*34	6/28/63	9	1.2	110.6	-6.9	49.3	49.087	-94.9	6*36* 3	9.5					342									

ORBIT NO.	CDA STA	REACJUT						ORBIT						TIME INTERVAL OF FILE ON FMR TAPE						FMR TAPE REEL NO.
		SATELLITE ORBITAL		EQUATOR CROSSING AT		SPIN	VECTOR	ATTITUDE		BEGIN	E N D		DROPOUTS, MINUTES							
		EARTH LONGI-ITUDE (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TIROS DAY			DECLI-NATION (DEG)	RIGHT ASCEN-SION (DEG)		MINI-MUM NADIR (DFG)	TOT (MIN. AFTER AND)	MINU-TES W/R/T AND	HOURS MINUTES SECONDS (GMT)	MINU-TES W/R/T AND	FROM- TO-				
132	1	-113.72	8* 3*59	6/28/63	9	1.1	110.5	-7.0	49.4	49.083	-82.0	8*16*33	12.6	-29.0	-27.0	342				
134	2	-163.17	11*18*43	6/28/63	9	1.0	110.4	-7.3	49.5	49.070	-90.8	11*32*33	13.8			342				
135	1	172.25	12*56*13	6/28/63	9	0.9	110.4	-7.4	49.5	49.065	-74.9	13*25*33	29.3			342				
136	1	147.58	14*33*37	6/28/63	9	0.9	110.3	-7.6	49.6	49.060	22.3	15* 6*24	32.8			342				
146	1	-99.15	6*47*43	6/29/63	10	-0.	110.2	-9.2	50.1	49.030	-69.0	6*59* 3	11.3			343				
148	2	-148.49	1.* 2*32	6/29/63	10	-0.1	110.2	-9.5	50.3	48.987	-93.6	10*13*33	11.0			343				
150	1	162.15	13*17*22	6/29/63	10	-0.3	110.1	-9.7	50.3	48.977	28.2	13*49*33	32.2			343				
151	1	137.48	14*54*46	6/29/63	10	-0.3	110.0	-9.9	50.3	48.970	-59.9	15*29* 3	34.3			343				
152	2	112.60	16*32*11	6/29/63	10	-0.4	110.0	-10.0	50.4	48.965	-57.8	17* 5* 3	32.9			343				
153	2	88.13	18* 9*35	6/29/63	10	-0.5	110.0	-10.2	50.4	48.959	-59.5	18*47* 3	37.5			343				
161	1	-109.25	7* 8*52	6/30/63	11	-1.2	109.9	-11.5	50.9	48.910	-93.1	7*20* 3	11.2			344				
163	2	-158.60	10*23*41	6/30/63	11	-1.3	109.8	-11.8	51.0	48.906	-91.8	10*36*33	12.9			344				
166	1	127.37	15*15*55	6/30/63	11	-1.4	109.7	-12.2	51.1	48.880	-58.5	15*51*33	35.6			344				
167	2	102.70	16*53*20	6/30/63	11	-1.5	109.6	-12.3	51.2	48.873	-55.6	17*26*33	33.2			344				
168	2	78.03	18*30*44	6/30/63	11	-1.6	109.6	-12.5	51.3	48.869	-56.4	19* 8*33	37.8			344				
175	1	-94.68	5*52*37	7/ 1/63	12	-2.0	109.5	-13.6	51.6	48.827	-95.2	6* 2* 3	9.4			345				
179	1	166.62	12*22*15	7/ 1/63	12	-2.0	109.2	-14.3	51.8	48.806	-73.8	12*53* 3	30.8			345				
180	1	141.95	13*59*40	7/ 1/63	12	-2.0	109.2	-14.5	51.7	48.801	25.3	14*33* 3	33.4			345				
181	2	117.27	15*37* 4	7/ 1/63	12	-2.0	109.2	-14.6	51.7	48.796	-59.0	16*10* 3	33.0			345				
182	2	92.60	17*14*29	7/ 1/63	12	-2.0	109.1	-14.8	51.8	48.791	-59.2	17*49*33	35.1			345				
190	1	-104.79	6*13*46	7/ 2/63	13	-2.2	108.8	-16.2	52.1	48.751	-93.2	6*25* 3	11.3			346				
192	2	-154.13	9*28*35	7/ 2/63	13	-2.2	108.7	-16.5	52.2	48.740	-94.1	9*39*33	11.0			346				
205	1	-114.88	6*34*55	7/ 3/63	14	-2.3	108.1	-18.7	52.7	48.673	-92.1	6*48* 3	13.1			347				
207	2	-164.23	9*49*44	7/ 3/63	14	-2.3	108.0	-19.0	52.8	48.663	-91.2	10* 3*33	13.8			347				
208	1	171.09	11*27* 8	7/ 3/63	14	-2.3	107.9	-19.1	52.8	48.657	-8.2	11*57*33	30.4			347				

ORBIT NO.	CDA STA	READOUT				ORBIT				TIME INTERVAL OF FILE ON FMR TAPE						FMR TAPE REEL NO.
		SATLLITE ORBITAL		EQUATOR CROSSING AT		SPIN VECTOR		ATTITUDE		BEGIN	E N D		DROPOUTS, MINUTES			
		EARTH LCNGI -TUDE (DEG)	HOURS MINUTES SECCNDS (GMT)	CALENDAR DATE	TIROS DAY	DECLI -NA -TION (DEG)	RIGHT ASCEN -SION (DEG)	MINI -MUM NADIR (DEG)	TOT (MIN. AFTER AND)		SPIN RATE (DEG /SEC)	MINU -TES W/R/T AND	HOURS MINUTES SECONDS (GMT)	MINU -TES W/R/T AND	FROM- TO-	
209	1	146.41	13* 4*33	7/ 3/63	14	-2.3	107.9	-19.3	52.7	48.652	-61.5	13*39*43	35.2			347
211	2	97.66	16*19*22	7/ 3/63	14	-2.3	107.8	-19.6	52.8	48.641	2.1	16*56* 3	36.7			347
220	2	-124.99	6*56* 4	7/ 4/63	15	-2.4	107.3	-21.1	53.1	48.593	-97.8	7* 3*33	7.5			348
223	1	160.98	11*48*18	7/ 4/63	15	-2.4	107.1	-21.5	53.3	48.576	-74.3	12*19*33	31.3			348
224	1	136.31	13*25*42	7/ 4/63	15	-2.4	107.1	-21.7	53.3	48.570	-60.7	14* 1*33	35.9			348
225	2	111.64	15* 3* 7	7/ 4/63	15	-2.4	107.0	-21.8	53.3	48.565	-56.4	15*36*33	33.4			348
233	1	-95.74	4* 2*24	7/ 5/63	16	-2.5	106.6	-23.1	53.6	48.519	-30.3	4*12* 3	9.7			349
234	1	-110.41	5*39*48	7/ 5/63	16	-2.5	106.5	-23.3	53.7	48.513	-82.3	5*51* 3	11.3			349
235	2	-135.68	7*17*13	7/ 5/63	16	-2.5	106.5	-23.4	53.7	48.507	-80.4	7*25* 3	7.8			349
236	2	-159.76	8*54*37	7/ 5/63	16	-2.5	106.4	-23.6	53.8	48.501	-84.2	9* 6*33	11.9			349
238	1	150.88	12* 9*26	7/ 5/63	16	-2.5	106.2	-23.9	53.8	48.489	-69.3	12*42*33	33.1			349
239	1	126.21	13*46*51	7/ 5/63	16	-2.4	106.2	-24.0	53.8	48.483	-58.8	14*23*33	36.7			349
240	2	101.54	15*24*16	7/ 5/63	16	-2.4	106.1	-24.2	53.8	48.477	-55.5	15*59* 3	34.8			349
241	2	76.87	17* 1*40	7/ 5/63	16	-2.5	106.1	-24.3	53.9	48.470	-56.0	17*40* 3	38.4			349
248	1	-95.84	4*23*32	7/ 6/63	17	-2.5	105.7	-25.4	54.2	48.427	-94.9	4*34* 3	10.5			350
249	1	-120.51	6* 0*57	7/ 6/63	17	-2.5	105.6	-25.6	54.1	48.420	-81.6	6*14*33	13.6			350
253	1	140.79	12*30*35	7/ 6/63	17	-2.4	105.3	-26.2	54.3	48.394	14.7	13* 4*33	34.0			350
254	2	116.11	14* 8* 0	7/ 6/63	17	-2.4	105.2	-26.3	54.3	48.388	-58.1	14*40*33	32.6			350
255	2	91.44	15*45*25	7/ 6/63	17	-2.4	105.2	-26.5	54.4	48.381	-58.8	16*21* 3	35.6			350
263	1	-105.94	4*44*41	7/ 7/63	18	-2.4	104.7	-27.7	54.6	48.345	-93.1	4*56* 3	11.4			351
264	2	-130.61	6*22* 6	7/ 7/63	18	-2.4	104.6	-27.9	54.7	48.339	-80.2	6*29*33	7.5			351
265	2	-155.28	7*59*31	7/ 7/63	18	-2.4	104.6	-28.0	54.7	48.332	-84.5	8*11*33	12.0			351
267	1	155.36	11*14*20	7/ 7/63	18	-2.4	104.4	-28.3	54.8	48.320	-72.0	11*47*33	33.2			351
268	1	130.69	12*51*44	7/ 7/63	18	-2.4	104.3	-28.5	54.9	48.313	-58.5	13*27* 3	35.3			351
269	2	106.01	14*29* 9	7/ 7/63	18	-2.4	104.2	-28.6	54.9	48.307	-56.4	15* 4*24	35.3			351

READOUT										ORBIT				TIME INTERVAL OF FILE ON FMR TAPE						FMR TAPE REEL NO.
ORBIT NO.	CDA STA	SATELLITE ORBITAL		EQUATOR CROSSING AT		SPIN DECLI- -NA- TION (DEG)	VECTOR RIGHT ASCEN- -SION (DEG)	ATTITUDE		SPIN RATE (DEG /SEC)	BEGIN			END		DROPOUTS, MINUTES W/R/T AND				
		EARTH LONGI- TUD (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TIROS DAY			MINI- MUM NADIR (DEG)	TOT (MIN. AFTER AND)		MINU- -TES W/R/T AND	HOURS MINUTES SECONDS (GMT)	MINU- -TES W/R/T AND	TO-						
270	2	81.34	16* 6*34	7/ 7/63	18	-2.4	104.2	-28.8	54.8	48.301	-57.6	16*43*24	36.8				351			
277	1	-91.36	3*29*26	7/ 8/63	19	-2.4	103.7	-29.8	55.2	48.256	-94.2	3*39* 3	10.6	-54.4	-53.4		352			
278	1	-116.54	5* 5*50	7/ 8/63	19	-2.4	103.7	-29.9	55.2	48.249	-81.5	5*20*33	14.7				352			
279	2	-140.71	6*43*15	7/ 8/63	19	-2.3	103.6	-30.1	55.3	48.243	-77.2	6*53*33	10.3				352			
281	1	169.93	9*58* 4	7/ 8/63	19	-2.3	103.4	-30.4	55.2	48.229	13.0	10*29*33	31.5				352			
282	1	145.26	11*35*29	7/ 8/63	19	-2.3	103.3	-30.5	55.3	48.223	-17.4	12* 9* 3	33.6				352			
284	2	95.91	14*50*18	7/ 8/63	19	-2.3	103.2	-30.8	55.4	48.210	-40.5	15*25* 3	34.8				352			
293	2	-126.15	5*26*59	7/ 9/63	20	-2.2	102.7	-32.2	55.7	48.151	-89.5	5*42*33	15.6				353			
294	2	-150.83	7* 4*24	7/ 9/63	20	-2.1	102.7	-32.4	55.8	48.145	-76.8	7*15*33	11.2				353			
296	1	159.81	13*19*13	7/ 9/63	20	-2.1	102.7	-32.8	55.8	48.132	-73.1	10*51*33	32.3	-26.2	-25.2		353			
297	1	135.14	11*56*38	7/ 9/63	20	-2.1	102.6	-33.0	55.9	48.125	-59.6	12*33* 3	36.4	-23.6	-21.6		353			
298	2	110.47	13*34* 2	7/ 9/63	20	-2.0	102.6	-33.2	56.0	48.119	-55.8	14* 7*33	33.5				353			
299	2	85.80	15*11*27	7/ 9/63	20	-2.0	102.6	-33.4	56.0	48.112	-58.5	15*48* 3	36.6				353			
306	1	-86.91	2*33*13	7/10/63	21	-1.1	102.5	-35.2	56.1	48.067	-97.7	2*41* 3	7.7				354			
307	1	-111.58	4*10*44	7/10/63	21	-1.3	102.1	-35.4	56.2	48.061	-84.6	4*23*33	12.8				354			
309	2	-160.93	7*25*33	7/10/63	21	-3.0	101.3	-34.4	56.5	48.048	-92.1	7*38*33	13.0				354			
311	1	149.72	10*40*22	7/10/63	21	-4.2	100.6	-33.4	56.6	48.036	-71.9	11*13*33	33.2	-22.4	-21.4		354			
312	1	125.14	12*17*47	7/10/63	21	-5.0	100.4	-32.9	56.7	48.029	-59.6	12*54*33	36.8				354			
313	2	100.37	13*55*11	7/10/63	21	-5.9	100.4	-32.4	56.9	48.023	-55.7	14*30* 3	34.9				354			
314	2	75.69	15*32*36	7/10/63	21	-6.8	100.5	-32.0	57.2	48.017	-57.4	16*11* 3	38.5				354			
321	1	-97.01	2*54*28	7/11/63	22	-12.1	101.1	-29.8	59.0	47.974	-95.0	3* 5* 3	10.6				355			
322	1	-121.68	4*31*53	7/11/63	22	-12.7	100.9	-29.4	59.2	47.968	-36.8	4*46*33	14.7				355			
323	2	-146.36	6* 9*17	7/11/63	22	-13.2	100.7	-29.0	59.3	47.962	-77.8	6*20*33	11.3				355			
325	1	164.29	9*24* 6	7/11/63	22	-14.3	100.1	-28.2	59.6	47.950	-72.9	9*56*33	32.5				355			
326	1	139.62	11* 1*31	7/11/63	22	-15.0	99.9	-27.8	59.7	47.944	-59.6	11*37*33	36.0				355			

READOUT										ORBIT					TIME INTERVAL OF FILE ON FMR TAPE					FMR TAPE REEL NO.
ORBIT NO.	CDA STA	SATELLITE ORBITAL		EQUATOR CROSSING AT		SPIN		VECTOR		ATTITUDE		BEGIN	E N D		DROPOUTS, MINUTES					
		LONGI (DEG)	LATITU (DEG)	HOURS MINUTES SECONDS (GMT)	DATE	CALENDAR DATE	TIROS DAY	DECLI -N -TION (DEG)	RIGHT -ASCEN -SION (DEG)	MINI -MUM NADIR (DEG)	TOT (MIN. AND)		SPIN RATE (/SEC)	MINU -TES W/R/T ANO	HOURS MINUTES SECONDS (GMT)	MINU -TES W/R/T ANO	FROM- W/R/T ANO	TO- W/R/T ANO		
328	2	90.27	14*16*20		7/11/63	22	-16.6	100.1	-26.9	60.1	47.932	-69.8	14*51*3	34.7					355	
337	2	-131.78	4*53*2		7/12/63	23	-22.8	102.2	-24.5	62.3	47.882	-96.8	5*1*3	8.0					356	
338	2	-156.45	6*30*26		7/12/63	23	-23.2	102.1	-24.2	62.5	47.876	-84.5	6*42*33	12.1					356	
340	1	154.19	9*45*15		7/12/63	23	-24.3	101.8	-23.6	62.6	47.866	-14.8	10*17*33	32.3					356	
341	1	129.52	11*22*40		7/12/63	23	-24.3	101.8	-23.2	62.7	47.860	-60.1	11*58*33	35.9					356	
342	2	104.84	13*0*5		7/12/63	23	-25.7	102.0	-22.8	62.9	47.855	-56.4	13*34*3	34.0					356	
343	2	80.17	14*37*29		7/12/63	23	-26.5	102.5	-22.4	63.2	47.850	-58.5	15*15*3	37.6					356	
350	1	-92.53	1*59*22		7/13/63	24	-30.7	105.9	-20.9	65.0	47.815	-95.8	2*9*3	9.7					357	
351	1	-117.21	3*36*46		7/13/63	24	-31.1	106.1	-20.8	65.2	47.810	-82.9	3*50*33	13.8					357	
354	1	168.76	8*29*0		7/13/63	24	-32.4	106.2	-20.1	65.6	47.795	-74.7	8*59*33	30.6					357	
356	1	119.42	11*43*49		7/13/63	24	-33.4	106.4	-19.5	65.9	58.200	-60.7	12*20*3	36.2					357	
357	2	94.74	13*21*14		7/13/63	24	-34.0	106.8	-19.2	66.1	58.195	-55.7	14*0*3	38.8					357	
365	1	-102.63	2*20*31		7/14/63	25	-37.1	111.4	-18.2	67.9	58.150	-92.0	2*34*3	13.5					358	
366	2	-127.31	3*57*55		7/14/63	25	-37.3	111.7	-18.1	68.0	58.145	-78.2	4*5*33	7.6					358	
367	2	-151.98	5*35*20		7/14/63	25	-37.5	111.8	-18.1	68.2	58.138	-84.5	5*47*33	12.2					358	
369	1	158.66	8*50*9		7/14/63	25	-38.0	112.1	-17.8	68.3	58.129	-72.7	9*23*3	32.9					358	
370	1	133.99	10*27*34		7/14/63	25	-38.4	112.3	-17.7	68.4	58.126	-57.8	11*4*33	37.0					358	
371	2	109.32	12*4*58		7/14/63	25	-38.8	112.7	-17.4	68.6	58.119	-55.1	12*39*3	34.1					358	
372	2	84.64	13*42*23		7/14/63	25	-39.3	113.4	-17.1	68.8	58.112	-58.1	14*20*3	37.7					358	
379	1	-88.66	1*4*15		7/15/63	26	-40.8	118.8	-16.6	70.4	58.065	-93.9	1*15*33	11.3					359	
380	1	-112.73	2*41*40		7/15/63	26	-40.9	119.2	-16.7	70.6	58.059	-80.8	2*54*33	12.9					359	
382	2	-162.68	5*56*29		7/15/63	26	-41.0	119.8	-16.7	70.9	58.045	-82.0	6*9*33	13.1					359	
383	1	173.24	7*33*54		7/15/63	26	-41.1	120.1	-16.7	71.0	58.039	-75.6	8*3*33	29.7					359	
384	1	149.56	9*11*18		7/15/63	26	-41.3	120.3	-16.6	71.1	58.032	-62.7	9*43*33	32.3					359	
385	1	123.69	10*48*43		7/15/63	26	-41.6	120.8	-16.5	71.3	58.025	-60.2	11*25*33	36.8					359	

ORBIT NO.	CDA STA	READOUT										ORBIT						TIME INTERVAL OF FILE ON FMR TAPE						FMR TAPE REEL NO.				
		SATELLITE ORBITAL				EQUATOR CROSSING AT				SPIN		VECTOR		ATTITUDE		SPIN		BEGIN	E N D		DROPOUTS, MINUTES W/R/T AND							
		EARTH LONGITUDE (DEG)	HOURS	MINUTES	SECONDS (GMT)	CALENDAR DATE	TIROS DAY	DECLINATION (DEG)	RIGHT ASCENSION (DEG)	MINIMUM NADIR (DEG)	TOTAL (MIN. AFTER AND)	RATE (DEG /SEC)	MINUTES W/R/T AND	HOURS MINUTES SECONDS (GMT)	MINUTES W/R/T AND	FROM- TO-												
386	2	99.22	12*26*	8		7/15/63	26	-41.9	121.5	-16.3	71.4	58.018	-55.7	13* 0*33	34.4												359.	
387	2	74.54	14*	3*32		7/15/63	26	-42.1	122.4	-16.1	71.6	58.012	-57.8	14*41*33	38.0													359
394	1	-98.17	1*25*25			7/16/63	27	-42.0	128.2	-16.0	73.3	57.964	-95.0	1*35*33	10.1													360
395	1	-122.65	3* 2*49			7/16/63	27	-41.9	128.7	-16.2	73.5	57.958	-82.5	3*17*33	14.7													360
396	2	-147.52	4*40*14			7/16/63	27	-41.8	129.0	-16.3	73.6	57.951	-77.7	4*50*33	10.3													360
398	1	163.12	7*55*	3		7/16/63	27	-41.7	129.5	-16.4	73.8	57.937	-74.0	8*26*33	31.5													360
399	1	138.45	9*32*28			7/16/63	27	-41.3	129.9	-16.4	73.9	57.930	-57.5	10* 7*33	35.1													360
400	2	113.78	11* 9*52			7/16/63	27	-41.9	130.5	-16.3	74.0	57.924	-57.3	11*42*33	32.7													360
401	2	89.10	12*47*17			7/16/63	27	-41.9	131.3	-16.1	74.2	57.917	-59.8	13*24*33	37.3													360
410	2	-132.95	3*23*58			7/17/63	28	-39.8	137.8	-16.8	76.3	57.856	-80.6	3*30*33	6.6													361
411	2	-157.62	5* 1*23			7/17/63	28	-39.5	138.0	-17.0	76.4	57.849	-85.6	5*13*33	12.2													361
413	1	153.02	8*16*12			7/17/63	28	-39.2	138.4	-17.2	76.7	57.835	-73.1	8*48*33	32.4													361
414	1	128.35	9*53*37			7/17/63	28	-39.1	138.8	-17.2	76.8	57.828	-60.1	10*29*33	35.9													361
415	2	103.68	11*31*	2		7/17/63	28	-39.1	139.4	-17.2	76.9	57.821	-56.7	12* 5*33	34.5													361
416	2	79.01	13* 8*26			7/17/63	28	-38.9	140.2	-17.1	77.1	57.815	-58.2	13*46*33	38.1													361
423	1	-93.70	0*30*19			7/18/63	29	-35.9	144.7	-17.8	78.8	57.767	-96.1	0*39*33	9.2													362
424	1	-118.37	2* 7*43			7/18/63	29	-35.4	144.9	-18.1	79.0	57.760	-81.0	2*22*43	15.0													362
427	1	167.60	6*59*57			7/18/63	29	-34.3	145.1	-18.9	79.3	57.739	-74.9	7*30*33	30.6													362
428	1	142.93	8*37*22			7/18/63	29	-34.1	145.3	-19.0	79.4	57.732	-18.1	9*11*54	34.5													362
429	2	118.25	10*14*46			7/18/63	29	-33.9	145.6	-19.1	79.5	57.725	-58.1	10*46*33	31.8													362
430	2	93.58	11*52*11			7/18/63	29	-33.6	146.2	-19.1	79.7	57.718	30.9	12*26* 3	33.9													362
437	1	-79.12	23*14*	3		7/18/63	29	-29.8	149.6	-20.0	81.3	57.670	-95.6	23*23*46	9.7													363
438	1	-103.80	0*51*28			7/19/63	30	-29.1	149.7	-20.3	81.6	57.663	-37.9	1* 1*19	9.9													363
439	2	-128.47	2*28*53			7/19/63	30	-28.6	149.7	-20.7	81.7	57.656	-82.1	2*36*33	7.7													363
440	2	-153.14	4* 6*17			7/19/63	30	-28.1	149.6	-21.0	81.9	57.650	-84.7	4*17*33	11.3													363

READOUT										ORBIT										TIME INTERVAL OF FILE ON FMR TAPE										FMR TAPE REEL NO.	
ORBIT NO.	CDA STA	SATELLITE			EQUATOR			CROSSING AT			SPIN			VECTOR			ATTITUDE			BEGIN	E N D			DROPOUTS, MINUTES W/R/T AND							
		EARTH LC'NGI -TIDE (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TROSS DAY	DECLI -NA -TION (DEG)	RIGHT ASCEN -SION (DEG)	MINI -MUM NADIR (DEG)	TOT (MIN. AND)	SPIN RATE (DEG /SEC)	TOT (MIN. AND)	MINU -TES W/R/T AND	HOURS MINUTES SECONDS (GMT)	MINU -TES W/R/T AND	FROM-	TO-															
442	1	157.50	7*21* 7	7/19/63	30	-27.4	149.5	-21.6	82.1	57.636	-72.9	7*53*33	32.4																		363
443	1	132.83	8*58*31	7/19/63	30	-27.1	149.6	-21.8	82.2	57.629	-60.0	9*34*33	36.0																		363
444	2	108.15	10*35*56	7/19/63	30	-26.7	149.9	-21.9	82.4	57.622	-56.3	11* 9*33	33.6																		363
445	2	83.48	12*13*21	7/19/63	30	-26.3	150.3	-21.9	82.5	57.615	-58.6	12*50*33	37.2																		363
452	1	-89.22	23*35*13	7/19/63	30	-21.7	152.3	-23.3	84.2	57.567	-95.5	23*44*33	9.3																		364
453	1	-113.89	1*12*38	7/20/63	31	-21.0	152.2	-23.7	84.4	57.560	-81.6	1*25*33	12.9																		364
454	2	-138.57	2*50* 2	7/20/63	31	-20.4	152.0	-24.2	84.5	57.553	-79.4	2*58*33	8.5																		364
455	2	-163.24	4*27*27	7/20/63	31	-19.9	151.8	-24.6	84.7	57.546	-75.9	4*40*33	13.1																		364
456	1	172.07	6* 4*51	7/20/63	31	-19.5	151.6	-24.9	84.7	57.539	-75.8	6*34*33	29.7																		364
457	1	147.40	7*42*16	7/20/63	31	-19.1	151.5	-25.2	84.8	57.532	-61.7	8*16*33	34.3																		364
458	1	122.73	9*19*41	7/20/63	31	-18.7	151.5	-25.5	84.9	57.525	-57.9	9*56*33	36.9																		364
459	2	98.05	10*57* 5	7/20/63	31	-18.3	151.7	-25.6	85.0	57.518	-54.9	11*32*33	35.5																		364
468	2	-123.99	1*33*47	7/21/63	32	-12.0	152.5	-28.0	87.0	57.456	-98.7	1*40*33	6.8																		365
469	2	-148.67	3*11*12	7/21/63	32	-11.4	152.2	-28.4	87.2	57.449	-85.6	3*22*33	11.4																		365
473	2	112.63	9*40*50	7/21/63	32	-9.6	151.4	-29.8	87.6	57.421	-56.5	10*13*33	32.7																		365
474	2	87.95	11*18*15	7/21/63	32	-9.1	151.5	-30.0	87.7	57.414	-59.4	11*55*33	37.3																		365
481	1	-84.75	22*40* 7	7/21/63	32	-3.9	151.6	-31.9	89.4	57.365	-39.5	22*47* 3	6.9																		366
482	1	-109.42	0*17*32	7/22/63	33	-4.0	151.6	-32.4	89.6	57.358	-32.1	0*29*33	12.0																		366
483	2	-134.09	1*54*57	7/22/63	33	-4.1	151.5	-32.2	89.6	57.351	-80.5	2* 3*33	8.6																		366
484	2	-158.77	3*22*22	7/22/63	33	-4.2	151.5	-31.9	89.5	57.344	-83.7	3*44*33	12.2																		366
486	1	151.88	6*47*11	7/22/63	33	-4.4	151.5	-31.4	89.6	57.331	-72.1	7*20*33	33.4																		366
487	1	127.20	9*24*36	7/22/63	33	-4.4	151.4	-31.2	89.7	57.324	-59.0	9* 0*33	36.0																		366
488	2	102.53	10* 2* 0	7/22/63	33	-4.5	151.4	-31.0	89.7	57.317	-56.5	10*36*33	34.6																		366
489	2	77.86	11*39*25	7/22/63	33	-4.6	151.3	-30.8	89.7	57.310	-57.7	12*16*33	37.1																		366
498	2	-144.25	2*16* 7	7/23/63	34	-5.5	151.0	-28.8	89.9	57.247	-78.4	2*24*33	8.4																		367



ORBIT NO.	CDA STA	READOUT										ORBIT										TIME INTERVAL OF FILE ON FMR TAPE						FMR TAPE REEL NO.		
		SATELLITE ORBITAL					EQUATOR CROSSING AT NOCE (ANO)					SPIN VECTOR					ATTITUDE					BEGIN	E N D			DROPOUTS, MINUTES				
		EARTH LONGITUDE (DEG)	HOURS	MINUTES	SECONDS (GMT)	ASCENDING	CALENDAR DATE	TIROS DAY	NOCE (ANO)	DECLINATION (DEG)	RIGHT ASCENSION (DEG)	M-VALUE (DEG)	M-VALUE (DEG)	TOT (MIN. AND)	SPIN RATE (DEG /SEC)	MINUTES W/R/T AND	SECONDS (GMT)	HOURS	MINUTES W/R/T AND	TO- FROM-	TO- FROM-									
500	1	166.39	5	30	56		7/23/63	34		-5.6	151.0	-28.3	90.0	57.233	-74.7	6	1	33	30.6										367	
501	1	141.72	7	8	21		7/23/63	34		-5.7	150.9	-28.1	90.0	57.226	-57.5	7	40	33	32.2											367
502	2	117.64	8	45	45		7/23/63	34		-5.8	150.9	-27.9	90.0	57.219	-53.3	9	17	33	31.8											367
503	2	92.37	10	23	10		7/23/63	34		-5.9	150.8	-27.7	90.0	57.212	-60.4	10	57	3	33.9											367
510	1	-80.34	21	45	2		7/23/63	34		-6.5	150.5	-26.1	90.2	57.164	-48.6	21	53	33	8.5											368
511	1	-105.11	23	22	27		7/23/63	34		-6.6	150.5	-25.9	90.2	57.157	-83.8	23	33	33	11.1											368
512	1	-129.68	0	59	52		7/24/63	35		-6.7	150.5	-25.7	90.2	57.150	-81.3	1	15	33	15.7											368
513	2	-154.35	2	37	16		7/24/63	35		-6.8	150.4	-25.5	90.2	57.143	-76.7	2	48	33	11.3											368
515	1	156.29	5	52	5		7/24/63	35		-6.9	150.4	-25.0	90.3	57.129	-72.9	6	24	33	32.5											368
516	1	131.62	7	29	30		7/24/63	35		-7.0	150.3	-24.8	90.3	57.122	-59.7	8	5	33	36.1											368
517	2	106.94	9	6	55		7/24/63	35		-7.1	150.3	-24.6	90.4	57.115	-56.0	9	40	33	33.6											368
526	1	-115.11	23	43	36		7/24/63	35		-7.9	149.9	-22.6	90.5	57.053	-92.2	23	56	33	13.0											369
528	2	-164.46	2	58	26		7/25/63	36		-8.1	149.8	-22.2	90.6	57.039	-85.6	3	11	33	13.1											369
529	1	170.85	4	35	50		7/25/63	36		-8.1	149.8	-22.0	90.6	57.033	-75.6	5	5	33	29.7											369
530	1	146.18	6	13	15		7/25/63	36		-8.2	149.8	-21.7	90.6	57.026	-62.1	6	47	33	34.3											369
531	1	121.51	7	50	39		7/25/63	36		-8.3	149.8	-21.5	90.6	57.019	-57.5	8	27	33	36.9											369
532	2	96.84	9	28	4		7/25/63	36		-8.3	149.7	-21.3	90.6	57.012	-55.0	10	3	33	35.5											369
533	2	72.16	11	5	29		7/25/63	36		-8.4	149.7	-21.1	90.7	57.005	-56.8	11	44	33	39.1											369
540	1	-100.54	22	27	21		7/25/63	36		-9.1	149.4	-19.6	90.7	56.957	-40.1	22	38	3	10.7											370
541	2	-125.22	0	4	46		7/26/63	37		-9.2	149.3	-19.3	90.8	56.950	-81.4	0	13	26	8.7											370
542	2	-149.89	1	42	10		7/26/63	37		-9.2	149.3	-19.1	90.8	56.943	-83.5	1	52	3	9.9											370
544	1	160.75	4	57	9		7/26/63	37		-9.4	149.3	-18.6	90.9	56.929	-73.8	5	28	3	31.1											370
545	1	136.08	6	34	24		7/26/63	37		-9.4	149.3	-18.4	90.9	56.923	-61.4	7	9	33	35.2											370
546	2	111.40	8	11	49		7/26/63	37		-9.4	149.2	-18.2	90.9	56.916	-57.4	8	45	33	33.7											370
547	2	86.73	9	49	14		7/26/63	37		-9.4	149.2	-18.1	91.0	56.909	-58.6	10	26	33	37.3											370

ORBIT NO.	CDA STA	READOUT					ORBIT					TIME INTERVAL OF FILE ON FMR TAPE					FMR TAPE REEL NO.			
		SATELLITE ORBITAL		EQUATOR ASCENDING		CROSSING AT (ANO)	SPIN	VECTOR	ATTITUDE		BEGIN	E N D			DROPOUTS, MINUTES					
		EARTH LONGITUDE (DEC)	LATITUDE (DEC)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE				TIROS DAY	DECLINATION (DEC)		RIGHT ASCENSION (DEC)	MINI-MUM NADIR (DEG)	TOT (MIN. AFTER AND)	SPIN RATE (DEG /SEC)	MINU-TES W/R/T AND		HOURS MINUTES SECONDS (GMT)	MINU-TES W/R/T AND	FROM- TO-
554	1	-85.97	21*11*6		7/26/63	37	-9.3	148.9	-16.9	91.3	56.861	-95.4	21*21*3	10.0			371			
555	1	-110.65	22*48*31		7/26/63	37	-9.3	148.9	-16.8	91.3	56.854	-82.2	23*0*33	12.0			371			
556	2	-135.32	0*25*55		7/27/63	38	-9.2	148.8	-16.6	91.4	56.847	-80.2	0*36*3	10.1			371			
557	2	-160.00	2*3*20		7/27/63	38	-9.2	148.8	-16.5	91.4	56.841	-82.0	2*16*27	13.1			371			
559	1	150.65	5*18*9		7/27/63	38	-9.2	148.7	-16.2	91.4	56.827	-72.0	5*51*33	33.4			371			
560	1	125.98	6*55*34		7/27/63	38	-9.2	148.6	-16.0	91.4	56.820	-58.7	7*32*33	37.0			371			
561	2	101.30	8*32*58		7/27/63	38	-9.2	148.6	-15.8	91.5	56.813	-54.9	9*7*3	34.1			371			
562	2	76.63	10*10*23		7/27/63	38	-9.2	148.6	-15.7	91.5	56.807	-58.0	10*48*33	38.2			371			
569	1	-96.18	21*32*15		7/27/63	38	-9.0	148.4	-14.5	91.8	56.759	-94.6	21*43*3	10.8			372			
570	1	-120.75	23*9*40		7/27/63	38	-9.0	148.3	-14.4	91.9	56.752	-80.8	23*23*33	13.9			372			
571	2	-145.43	0*47*5		7/28/63	39	-9.0	148.3	-14.2	91.9	56.745	-78.3	0*59*3	12.0	-26.1	-25.1	372			
573	1	165.22	4*1*54		7/28/63	39	-9.0	148.2	-13.9	92.0	56.732	-63.9	4*32*33	30.7			372			
574	1	140.54	5*39*19		7/28/63	39	-8.9	148.1	-13.7	92.1	56.725	-54.7	6*13*33	34.2			372			
575	2	115.87	7*16*43		7/28/63	39	-8.9	148.1	-13.6	92.1	56.718	-51.5	7*50*3	33.3			372			
576	2	91.20	8*54*8		7/28/63	39	-8.9	148.1	-13.4	92.2	56.712	-51.6	9*30*33	36.4			372			
584	1	-106.19	21*53*25		7/28/63	39	-8.7	147.8	-12.1	92.5	56.658	-74.1	22*6*3	12.6			373			
586	2	-155.53	1*8*14		7/29/63	40	-8.7	147.8	-11.7	92.6	56.645	-80.8	1*21*3	12.8			373			
588	1	155.11	4*23*3		7/29/63	40	-8.6	147.7	-11.4	92.6	56.631	-59.2	4*55*33	32.5			373			
589	1	130.44	6*0*28		7/29/63	40	-8.6	147.6	-11.3	92.6	56.624	-52.7	6*36*33	36.1	-25.5	-24.5	373			
591	2	81.09	9*15*17		7/29/63	40	-8.6	147.6	-10.9	92.7	56.611	-40.0	9*52*33	37.3			373			
599	1	-116.29	22*14*34		7/29/63	40	-8.3	147.4	-9.5	93.0	56.558	-79.3	22*27*33	13.0			374			
603	1	145.01	4*44*13		7/30/63	41	-8.2	147.2	-8.9	93.2	56.531	-56.9	5*18*33	34.3	-24.2	-23.2	374			
605	2	95.66	7*59*2		7/30/63	41	-8.2	147.2	-8.6	93.3	56.518	-53.5	8*34*3	35.0			374			
613	1	-101.72	20*58*19		7/30/63	41	-7.9	147.0	-7.2	93.6	56.466	-74.0	21*9*33	11.2			375			
615	2	-151.06	0*13*8		7/31/63	42	-7.8	146.9	-6.9	93.8	56.453	-75.1	0*24*3	10.9			375			

ORBIT NO.	CDA STA	READOUT					ORBIT					TIME INTERVAL OF FILE ON FMR TAPE					FMR TAPE REEL NO.
		SATELLITE ORBITAL		EQUATOR CROSSING AT		ATITUDE	SPIN		VECTOR		SPIN RATE (DEG / SEC)	BEGIN	E N D		DROPOUTS, MINUTES W/R/T AND		
		EARTH LONGI-TUDE (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TIROS DAY		DECLI-NATION (DEG)	RIGHT ASCEN-SION (DEG)	MINI-MUM NADIR (DEG)	TOT (MIN. AFTER ANO)			HOURS MINUTES SECONDS (GMT)	MINU-TES W/R/T AND			
617	1	159.58	3*27*57	7/31/63	42	-7.7	146.9	-6.5	93.8	56.440	-58.3	3*58*33	30.6			375	
619	2	110.23	6*42*46	7/31/63	42	-6.5	146.8	-6.4	93.9	56.426	-46.1	7*15*33	32.8			375	
620	2	85.56	8*20*11	7/31/63	42	-5.5	146.9	-6.7	94.2	56.420	-51.8	8*57*33	37.4			375	
627	1	-87.15	19*42*3	7/31/63	42	2.4	146.8	-9.2	96.2	56.375	-83.8	19*51*3	9.0			376	
628	1	-111.82	21*19*28	7/31/63	42	3.4	146.5	-9.7	96.5	56.368	-75.0	21*32*3	12.6			376	
630	2	-161.17	0*34*17	8/ 1/63	43	5.1	145.8	-10.9	96.9	56.355	-81.8	0*46*33	12.3			376	
632	1	149.48	3*49*7	8/ 1/63	43	6.6	145.0	-11.9	97.3	56.342	-59.8	4*21*33	32.4			376	
634	2	100.13	7*3*56	8/ 1/63	43	8.3	144.6	-13.0	0.2	56.330	-53.4	7*38*33	34.6			376	
642	1	-97.25	20*3*13	8/ 1/63	43	17.1	144.1	-15.9	2.5	56.279	-86.9	20*13*3	9.8	-28.2	-27.2	377	
644	2	-146.59	23*18*2	8/ 1/63	43	18.9	143.4	-17.0	3.0	56.266	-62.2	23*28*3	10.0	-19.0	-17.0	377	
647	1	139.38	4*10*16	8/ 2/63	44	21.2	142.1	-18.5	3.5	56.247	-51.3	4*43*33	33.3			377	
649	2	30.03	7*25*5	8/ 2/63	44	23.0	141.7	-19.4	3.9	56.234	-37.3	8*1*33	36.5			377	
658	2	-132.02	22*1*47	8/ 2/63	44	32.6	140.4	-22.7	6.5	56.178	-68.5	22*9*33	7.8			378	
659	2	-156.69	23*39*11	8/ 2/63	44	33.4	139.9	-23.1	5.8	56.172	-76.6	23*51*3	11.9			378	
661	1	153.95	2*54*1	8/ 3/63	45	34.9	139.0	-24.1	7.2	56.159	-60.2	3*26*33	32.5			378	
662	1	179.27	4*31*25	8/ 3/63	45	35.6	138.5	-24.5	7.4	56.153	-51.7	5*6*33	35.1			378	
672	1	-117.45	20*45*31	8/ 3/63	45	45.3	137.2	-27.8	10.3	56.092	-78.9	20*58*33	13.0			379	
673	2	-142.12	22*22*56	8/ 3/63	45	45.2	137.3	-27.4	10.4	56.085	-70.4	22*33*3	10.1			379	
678	2	94.50	6*29*59	8/ 4/63	46	44.7	137.3	-26.4	10.3	56.055	-37.7	7*5*33	35.6			379	
686	1	-102.88	19*29*16	8/ 4/63	46	43.7	137.1	-24.8	10.1	56.007	-77.6	19*40*3	10.8			380	
687	2	-127.55	21*6*41	8/ 4/63	46	43.6	137.1	-24.6	10.1	56.001	-72.4	21*14*3	7.4			380	
688	2	-152.22	22*44*5	8/ 4/63	46	43.5	137.1	-24.4	10.1	55.995	-75.7	22*55*3	11.0			380	
690	1	158.42	1*58*55	8/ 5/63	47	43.3	137.1	-24.0	10.1	55.983	-60.6	2*29*33	30.6			380	
691	1	133.75	3*36*19	8/ 5/63	47	43.2	137.1	-23.8	10.1	55.977	-53.5	4*11*33	35.2			380	
692	2	109.07	5*13*44	8/ 5/63	47	43.1	137.1	-23.5	10.2	55.971	-47.4	5*47*3	33.3			380	

READOUT										ORBIT										TIME INTERVAL OF FILE ON FMR TAPE										FMR TAPE REEL NO.		
ORBIT NO.	CDA STA	SATELLITE EQUATOR CROSSING AT				SPIN VECTOR ATTITUDE				BEGIN MINU -TES W/R/T AND	E N D				DROPOUTS, MINUTES W/R/T AND																	
		ORBITAL ASCENDING		NODE (LONG)		DECLI -NA -TION (DEG)	RIGHT ASCEN -SION (DEG)	MINI -MUM VADIR (DEG)	TOT (MIN. AFTER AND)		SPIN RATE (DEG /SEC)	HOURS MINUTES SECONDS (GMT)	MINU -TES W/R/T AND	MINU -TES W/R/T AND	FROM-- TO--																	
		EARTH LONGI -TUDE (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TIRUS DAY																											
702	2	-137.65	21*27*50	8/ 5/63	47	41.9	136.9	-21.5	10.0	55.912	-68.5	21*37* 3	9.2																		381	
705	1	148.29	2*20* 4	8/ 6/63	48	41.6	136.9	-20.8	9.9	55.895	-57.8	2*53*33	33.5																			381
706	1	123.62	3*57*28	8/ 6/63	48	41.5	136.9	-20.6	10.0	55.889	-50.8	4*33*33	36.1																			381
715	1	-98.43	18*34*10	8/ 6/63	48	40.5	136.7	-18.8	9.9	55.838	-87.8	18*45* 3	10.9																			382
717	2	-147.78	21*48*59	8/ 6/63	48	40.3	136.7	-18.4	9.9	55.826	-73.5	21*59*33	10.6																			382
719	1	162.86	1* 3*48	8/ 7/63	49	40.1	136.7	-17.9	9.9	55.815	-60.5	1*34*33	30.8																			382
720	1	138.19	2*41*13	8/ 7/63	49	40.0	136.7	-17.7	9.9	55.809	-53.0	3*15*33	34.3																			382
722	2	88.84	5*56* 2	8/ 7/63	49	39.8	136.6	-17.3	9.9	55.798	-55.6	6*32*33	36.5																			382
729	1	-83.86	17*17*54	8/ 7/63	49	39.0	136.4	-15.9	9.9	55.759	-86.8	17*29* 3	11.2																			383
730	1	-108.53	18*55*19	8/ 7/63	49	38.9	136.4	-15.6	9.9	55.754	-72.7	19* 7*33	12.2																			383
731	2	-133.21	20*32*44	8/ 7/63	49	38.9	136.4	-15.4	9.9	55.748	-69.5	20*40* 3	7.3																			383
735	1	128.09	3* 2*22	8/ 8/63	50	38.5	136.4	-14.6	9.9	55.706	-51.1	3*38*33	36.2																			383
736	2	103.42	4*39*47	8/ 8/63	50	38.4	136.4	-14.4	9.9	55.700	-47.3	5*14* 3	34.3																			383
737	2	78.74	6*17*11	8/ 8/63	50	38.3	136.4	-14.2	9.9	55.694	-50.0	6*55*33	38.4																			383
744	1	-93.96	17*39* 4	8/ 8/63	50	37.6	136.2	-12.7	9.9	55.654	-84.4	17*50* 3	11.0																			384
745	1	-118.64	19*16*28	8/ 8/63	50	37.5	136.2	-12.5	9.9	55.648	-73.5	19*30* 3	13.6																			384
748	1	167.34	0* 8*42	8/ 9/63	51	37.3	136.2	-11.9	9.9	55.631	-61.4	0*39* 3	30.4																			384
749	1	142.66	1*46* 7	8/ 9/63	51	37.2	136.2	-11.7	10.0	55.625	-33.4	2*18*33	32.4																			384
751	2	93.32	5* 0*56	8/ 9/63	51	37.0	136.1	-11.3	10.0	55.614	-39.8	5*36* 3	35.1																			384
761	2	-153.41	21*15* 2	8/ 9/63	51	36.3	135.8	-9.3	10.1	55.558	-80.2	21*27* 3	12.0																			385
764	1	132.56	2* 7*16	8/10/63	52	36.4	135.8	-8.9	10.1	55.541	-51.8	2*42*33	35.3																			385
765	2	107.89	3*44*40	8/10/63	52	36.4	135.7	-8.7	10.2	55.536	-48.5	4*18*33	33.9																			385
766	2	83.21	5*22* 5	8/10/63	52	36.5	135.7	-8.6	10.2	55.530	-50.8	5*59* 3	37.0																			385
774	1	-114.17	18*21*22	8/10/63	52	36.7	135.7	-7.4	10.5	55.487	-58.5	18*34* 3	12.7																			386
775	2	-138.84	19*58*47	8/10/63	52	36.8	135.7	-7.3	10.5	55.481	-74.6	20*10* 3	11.3																			386

READOUT										ORBIT				TIME INTERVAL OF FILE ON FMR TAPE						FMR TAPE REEL NO.
ORBIT NO.	COA STA	SATELLITE ORBITAL		EQUATOR CROSSING AT		SPIN		VECTOR		ATTITUDE		BEGIN	E N D		DROPOUTS, MINUTES W/R/T AND					
		EARTH LONGI -TUDF (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TIROS DAY	DECLI -NA -TION (DEG)	RIGHT ASCEN -SION (DEG)	MINI -MUM NADIR (DEG)	TOT (MIN. AND)	SPIN RATE (DEG /SEC)	MINU -TES W/R/T AND		HOURS MINUTES SECONDS (GMT)	MINU -TES W/R/T AND	TO-					
776	2	-163.51	21*36*11	8/11/63	52	36.8	135.7	-7.1	10.6	55.476	13.4	-75.1	21*49*33	13.4			386			
779	1	122.46	2*28*25	8/11/63	53	36.9	135.6	-6.7	10.7	55.460	36.6	-53.7	3*5*3	36.6			386			
780	2	97.78	4*5*50	8/11/63	53	36.9	135.6	-6.6	10.8	55.454	35.2	-49.0	4*41*3	35.2			386			
788	1	-99.59	17*5*7	8/11/63	53	37.2	135.6	-5.4	11.1	55.411	9.9	-64.4	17*15*3	9.9			387			
789	1	-124.27	19*42*31	8/11/63	53	37.3	135.6	-5.3	11.1	55.406	15.5	-67.8	18*58*3	15.5			387			
790	2	-148.94	20*19*56	8/11/63	53	37.3	135.6	-5.1	11.2	55.401	10.6	-71.6	20*30*33	10.6			387			
792	1	161.77	23*34*45	8/11/63	53	37.3	135.5	-4.9	11.2	55.390	31.3	-64.3	0*6*3	31.3			387			
793	1	137.03	1*12*10	8/12/63	54	37.4	135.5	-4.7	11.2	55.385	33.9	-56.0	1*46*3	33.9			387			
794	2	112.36	2*49*34	8/12/63	54	37.4	135.5	-4.6	11.3	55.380	33.5	-53.2	3*23*3	33.5			387			
795	2	87.68	4*26*59	8/12/63	54	37.4	135.5	-4.5	11.3	55.374	36.6	-52.9	5*3*33	36.6			387			
802	1	-85.02	15*48*51	8/12/63	54	37.7	135.6	-3.5	11.6	55.337	8.7	-85.8	15*57*33	8.7			388			
803	1	-109.69	17*26*15	8/12/63	54	37.8	135.6	-3.4	11.6	55.332	11.8	-77.2	17*38*3	11.8			388			
805	2	-159.04	20*41*5	8/12/63	54	37.8	135.6	-3.1	11.7	55.322	13.0	-79.9	20*54*3	13.0			388			
807	1	151.60	23*55*54	8/12/63	54	37.9	135.5	-2.8	11.8	55.311	32.2	-61.6	0*28*3	32.2			388			
808	1	126.92	1*33*19	8/13/63	55	37.9	135.5	-2.7	11.9	55.306	35.7	-54.8	2*9*3	35.7			388			
809	2	102.24	3*10*43	8/13/63	55	38.0	135.5	-2.6	11.9	55.301	34.3	-51.5	3*45*3	34.3			388			
810	2	77.57	4*48*8	8/13/63	55	38.0	135.6	-2.4	12.0	55.295	38.4	-52.1	5*26*33	38.4			388			
818	1	-119.81	17*47*25	8/13/63	55	38.2	135.8	-1.3	12.3	55.254	15.1	-78.9	18*2*33	15.1			389			
821	1	166.17	22*39*38	8/13/63	55	38.0	135.8	-0.7	12.4	55.238	30.4	-66.9	23*10*3	30.4			389			
831	1	-80.56	14*53*44	8/14/63	56	37.3	135.7	1.3	12.6	55.186	9.3	-95.4	15*3*3	9.3			390			
832	1	-105.23	16*31*9	8/14/63	56	37.2	135.7	1.4	12.6	55.181	12.4	-78.5	16*43*33	12.4			390			
836	1	156.06	23*0*47	8/14/63	56	37.0	135.8	2.2	12.7	55.160	32.3	-8.4	23*33*3	32.3			390			
837	1	131.39	5*38*12	8/15/63	57	36.9	135.8	2.4	12.8	55.155	35.9	-54.7	1*14*3	35.9			390			
838	2	106.72	2*15*37	8/15/63	57	36.9	135.8	2.6	12.8	55.150	34.4	-51.3	2*50*3	34.4			390			
839	2	82.04	3*53*1	8/15/63	57	36.8	135.8	2.8	12.8	55.145	37.0	-51.8	4*30*3	37.0			390			

READOUT										ORBIT										TIME INTERVAL OF FILE ON FMR TAPE										FMR TAPE REEL NO.		
ORBIT NO.	CDA STA	SATELLITE EQUATOR CROSSING AT				SPIN	VECTOR		ATTITUDE		SPIN RATE (DEG /SEC)	BEGIN	E N O				DROPOUTS, MINUTES															
		ORBITAL ASCENDING NODE (ANO)		TIROS			DECLI -NA TION (DEG)	RIGHT ASCEN -SION (DEG)	MINI -MUM NADIR (DEG)	TOT (MIN. AFTER AND)			MINU -TES W/R/T AND	HOURS MINUTES SECONDS (GMT)	MINU -TES W/R/T AND	FROM-	TO-															
		EARTH LONGI -TITUDE (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	DAY																											
846	1	-90.66	15*14*54	8/15/63	57	36.3	135.7	4.1	13.0	55.109	-85.5	15*25*3	10.2																		391	
847	1	-115.33	16*52*19	8/15/63	57	36.3	135.7	4.3	13.0	55.103	-75.3	17*6*3	13.8																			391
851	1	145.96	23*21*57	8/15/63	57	36.1	135.8	5.0	13.2	55.083	-57.6	23*56*25	34.5																			391
853	2	96.62	2*36*46	8/16/63	58	36.0	135.8	5.4	13.2	55.072	-31.3	3*11*33	34.8																			391
861	1	-100.76	15*36*3	8/16/63	58	35.5	135.7	6.9	13.5	55.031	-76.4	15*47*3	11.0																			392
865	1	160.54	22*5*41	8/16/63	58	35.3	135.8	7.6	13.6	55.010	-59.9	22*37*27	31.8																			392
866	1	135.86	23*43*6	8/16/63	58	35.3	135.9	7.8	13.6	55.004	-53.2	0*19*11	36.1																			392
868	2	86.52	2*57*55	8/17/63	59	35.2	135.9	8.2	13.7	54.994	-57.0	3*35*3	37.1																			392
875	1	-86.19	14*19*47	8/17/63	59	34.8	135.8	9.4	13.9	54.957	-84.8	14*29*27	9.7																			393
881	1	125.76	0*4*15	8/18/63	60	34.6	136.0	10.4	14.1	54.925	-53.7	0*41*3	36.8																			393
882	2	101.09	1*41*39	8/18/63	60	34.5	135.9	10.6	14.2	54.920	-49.5	2*16*3	34.4																			393
890	1	-96.29	14*45*56	8/18/63	60	34.1	135.3	11.7	14.4	54.877	-75.9	14*51*3	10.1																			394
892	2	-145.64	17*55*46	8/18/63	60	34.1	135.3	11.9	14.4	54.867	-64.2	18*7*3	11.3																			394
894	1	165.11	21*10*35	8/18/63	60	34.1	135.3	12.2	14.5	54.856	-63.8	21*41*3	30.5																			394
895	1	140.33	22*47*59	8/18/63	60	34.1	135.3	12.3	14.6	54.850	-56.6	23*24*3	36.1																			394
896	2	115.66	0*25*24	8/19/63	61	34.1	135.3	12.5	14.7	54.845	-50.9	0*57*33	32.2																			394
904	1	-81.72	13*24*41	8/19/63	61	33.7	134.7	13.5	14.8	54.801	-79.3	13*34*3	9.4																			395
906	2	-131.16	16*39*30	8/19/63	61	33.7	134.7	13.7	14.9	54.790	-66.0	16*48*3	8.6																			395
909	1	154.90	21*31*44	8/19/63	61	33.7	134.8	14.1	15.1	54.774	-64.1	22*4*3	32.3																			395
910	1	130.23	23*9*8	8/19/63	61	33.7	134.8	14.2	15.2	54.768	-55.2	23*45*3	35.9																			395
911	2	105.55	0*46*33	8/20/63	62	33.7	134.8	14.3	15.2	54.763	-51.7	1*21*3	34.5																			395
912	2	80.87	2*23*57	8/20/63	62	33.7	134.7	14.4	15.2	54.757	-52.5	3*1*33	37.6																			395
919	1	-91.83	13*45*50	8/20/63	62	33.4	134.3	15.3	15.5	54.712	-79.3	13*55*3	9.2																			396
921	2	-141.18	17*0*39	8/20/63	62	33.4	134.4	15.5	15.6	54.705	-63.3	17*10*3	9.4																			396
925	1	120.12	23*30*17	8/20/63	62	33.5	134.5	16.0	15.8	54.686	-57.5	0*8*33	38.3																			396

ORBIT NO.	CDA STA	READOUT										ORBIT										TIME INTERVAL OF FILE ON FMR TAPE						FMR TAPE REEL NO.						
		SATELLITE ORBITAL					EQUATOR CROSSING AT					SPIN VECTOR		ATTITUDE			SPIN RATE		BEGIN	E N D			DROPOUTS, MINUTES											
		EARTH LG 401		ASCENDING NODE (LANO)			DATE		TIROS DAY			DECLI -NA -TION (DEG)		RIGHT ASCEN -SION (DEG)		MINI -MUM NADIR (DEG)		TOT (MIN. AFTER AND)		SPIN RATE (DEG /SEC)		MINU -TES W/R/T AND		HOURS MINUTES SECONDS (GMT)		MINU -TES W/R/T AND			FROM- TO-					
		LOC	TIME (DEC)	HOURS	MINUTES	SECONDS (GMT)	DATE	DAY	DATE	DAY	DECLI -NA -TION (DEG)	RIGHT ASCEN -SION (DEG)	MINI -MUM NADIR (DEG)	TOT (MIN. AFTER AND)	SPIN RATE (DEG /SEC)	MINU -TES W/R/T AND	MINU -TES W/R/T AND	MINU -TES W/R/T AND		MINU -TES W/R/T AND	MINU -TES W/R/T AND	MINU -TES W/R/T AND	MINU -TES W/R/T AND	MINU -TES W/R/T AND	MINU -TES W/R/T AND	MINU -TES W/R/T AND	MINU -TES W/R/T AND		MINU -TES W/R/T AND	MINU -TES W/R/T AND	MINU -TES W/R/T AND	MINU -TES W/R/T AND		
926	2	95.45	1*	7*42			8/21/63	63				33.4	134.4	16.1	15.9	54.680	-23.4	1*41*33							1*41*33	33.9							396	
934	1	-101.93	14*	6*58			8/21/63	63				32.9	133.8	17.2	16.0	54.640	-31.0	14*19*	3							14*19*	3							397
936	2	-151.28	17*21	48			8/21/63	63				32.8	134.0	17.5	16.1	54.630	-79.0	17*32*33								17*32*33	10.8							397
938	1	159.37	20*36	37			8/21/63	63				32.8	134.1	17.9	16.3	54.620	-63.5	21* 8*33								21* 8*33	31.9							397
939	1	134.69	22*14	1			8/21/63	63				32.7	134.1	18.0	16.4	54.615	-55.2	22*50*	3							22*50*	3							397
940	2	110.02	23*51	26			8/21/63	63				32.7	134.1	18.1	16.4	54.610	-51.6	0*26*	3							0*26*	3							397
941	2	85.35	1*28	51			8/22/63	64				32.6	134.0	18.3	16.5	54.605	-52.5	2* 6*33								2* 6*33	37.7							397
948	1	-87.36	12*50	43			8/22/63	64				32.1	133.5	19.3	16.6	54.568	-85.2	13* 0* 3								13* 0* 3	9.3							398
949	1	-112.03	14*28	7			8/22/63	64				32.0	133.6	19.4	16.7	54.563	-77.2	14*41*	3							14*41*	3							398
950	2	-136.70	16* 5	32			8/22/63	64				32.0	133.7	19.6	16.8	54.557	-67.7	16*14*	3							16*14*	3							398
951	2	-161.38	17*42	57			8/22/63	64				32.0	133.8	19.7	16.8	54.552	-78.3	17*56*	3							17*56*	3							398
953	1	149.27	20*57	46			8/22/63	64				31.9	134.0	20.1	16.9	54.542	-61.9	21*31*	3							21*31*	3							398
954	1	124.59	22*35	10			8/22/63	64				31.8	134.0	20.3	17.0	54.537	-54.0	23*12*	3							23*12*	3							398
955	2	39.92	0*12	35			8/23/63	65				31.8	134.0	20.4	17.0	54.532	-50.6	0*48*	3							0*48*	3							398
956	2	75.25	1*50	0			8/23/63	65				31.7	133.9	20.6	17.1	54.527	-51.2	2*28*33								2*28*33	38.6							398
963	1	-97.46	13*11	52			8/23/63	65				31.3	133.6	21.5	17.3	54.490	-85.5	13*23*	3							13*23*	3							399
964	1	-122.13	14*49	16			8/23/63	65				31.2	133.6	21.6	17.4	54.485	-76.1	15* 4* 3								15* 4* 3	14.8							399
967	1	163.84	19*41	30			8/23/63	65				31.1	133.7	22.0	17.6	54.470	-68.0	20*13*	3							20*13*	3							399
968	1	139.17	21*18	55			8/23/63	65				31.0	133.7	22.2	17.6	54.465	-55.1	21*56*	3							21*56*	3							399
969	2	114.49	22*56	19			8/23/63	65				31.0	133.7	22.3	17.7	54.460	-50.3	23*29*	3							23*29*	3							399
970	2	89.82	0*33	44			8/24/63	66				30.9	133.7	22.5	17.8	54.455	-54.0	1*12*	3							1*12*	3							399
977	1	-82.69	11*55	36			8/24/63	66				30.5	133.3	23.4	18.0	54.416	-86.1	12* 4* 3								12* 4* 3	8.5							400
978	1	-107.56	13*33	1			8/24/63	66				30.5	133.3	23.5	18.1	54.412	-79.1	13*45*33								13*45*33	12.5							400
980	2	-156.90	16*47	50			8/24/63	66				30.4	133.3	23.7	18.2	54.404	-83.5	16*58*33								16*58*33	10.7							400
982	1	153.74	20* 2	39			8/24/63	66				30.4	133.4	23.9	18.3	54.396	-64.3	20*35*	3							20*35*	3							400

READOUT										ORBIT					TIME INTERVAL OF FILE ON FMR TAPE							FMR TAPE REEL NO.
ORBIT NO.	CDA STA	SATELLITE ORBITAL			EQUATOR CROSSING AT		SPIN VECTOR		ATTITUDE			BEGIN		END			DROPOUTS, MINUTES					
		EARTH LONGI- TUD (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TIRUS DAY	DECLI- NA- TION (DEG)	RIGHT ASCEN- SION (DEG)	MINI- MUM NADIR (DEG)	TOT (MIN. AND AFTER)	SPIN RATE (DEG /SEC)	MINU- TES W/R/T AND	HOURS MINUTES SECONDS (GMT)	MINU- TES W/R/T AND	FROM-	TO-							
983	1	129.67	21*40*4	8/24/63	66	30.3	133.4	24.0	18.3	54.391	-55.0	22*16*3	36.0				400					
984	2	104.39	23*17*28	8/24/63	66	30.3	133.4	24.2	18.4	54.387	-51.7	23*52*24	34.9				400					
985	2	79.72	1*54*53	8/25/63	67	30.2	133.4	24.3	18.5	54.382	-52.4	1*33*3	38.2				400					
992	1	-92.98	12*16*45	8/25/63	67	29.9	133.0	25.0	18.7	54.345	-84.8	12*27*3	10.3				401					
993	1	-117.66	13*54*10	8/25/63	67	29.9	133.0	25.1	18.8	54.340	-76.0	14*8*27	14.3				401					
994	2	-142.33	15*31*34	8/25/63	67	29.9	133.0	25.2	18.9	54.334	-7.5	15*39*33	8.0				401					
996	1	168.32	18*46*23	8/25/63	67	29.9	133.1	25.4	19.0	54.322	-67.2	19*16*33	30.2				401					
997	1	143.64	20*23*48	8/25/63	67	29.9	133.1	25.5	19.1	54.316	18.6	20*56*3	32.3				401					
999	2	94.29	23*38*37	8/25/63	67	29.7	133.1	25.7	19.3	54.304	-22.3	0*14*3	35.4				401					
1006	1	-78.41	11*0*29	8/26/63	68	29.5	132.8	26.4	19.6	54.262	-88.8	11*9*3	8.6	-15.5			402					
1008	1	-127.76	14*15*18	8/26/63	68	29.5	132.8	26.5	19.7	54.249	-80.9	14*31*3	15.8				402					
1009	2	-152.43	15*52*43	8/26/63	68	29.5	132.8	26.5	19.8	54.243	-71.0	16*3*3	10.3				402					
1011	1	158.21	19*7*32	8/26/63	68	29.5	132.9	26.7	19.9	54.231	-62.9	19*40*3	32.5				402					
1012	1	133.54	2*44*57	8/26/63	68	29.5	132.9	26.7	20.0	54.225	-54.7	21*20*3	35.1				402					
1013	2	1*8.87	22*22*21	8/26/63	68	29.5	132.9	26.8	20.0	54.219	-51.2	22*56*3	33.7				402					
1014	2	84.17	23*39*46	8/26/63	68	29.4	132.9	26.9	20.1	54.214	-53.2	0*36*3	36.3				402					
1021	1	-88.54	11*21*39	8/27/63	69	29.4	132.6	27.4	20.5	54.175	-87.4	11*30*3	8.4				403					
1026	1	148.19	19*28*41	8/27/63	69	29.4	132.8	27.6	20.8	54.151	-66.0	20*2*3	33.4				403					
1027	1	123.41	21*6*6	8/27/63	69	29.4	132.8	27.6	20.9	54.147	0.9	21*43*3	37.0				403					
1028	2	98.74	22*43*30	8/27/63	69	29.3	132.8	27.7	21.0	54.143	-50.2	23*19*27	36.0				403					
1036	1	-98.64	11*42*47	8/28/63	70	29.3	132.4	28.1	21.4	54.105	-88.9	11*52*33	9.8				404					
1040	1	162.66	18*12*25	8/28/63	70	29.4	132.6	28.1	21.7	54.083	-68.1	18*43*3	30.6				404					
1041	1	137.98	13*49*50	8/28/63	70	29.4	132.6	28.2	21.8	54.078	-56.5	20*25*3	35.2				404					
1042	2	113.31	21*27*14	8/28/63	70	29.4	132.6	28.2	21.9	54.072	-52.3	22*0*3	32.8				404					
1043	2	88.64	23*4*39	8/28/63	70	29.3	132.6	28.3	21.9	54.066	-53.5	23*42*3	37.4				404					



ORBIT NO.	CDA STA	READOUT					ORBIT					TIME INTERVAL OF FILE ON FMR TAPE					FMR TAPE REEL NO.
		SATELLITE ORBITAL		ASCENDING CROSSING AT		TITROS DAY	SPIN VECTOR		ATTITUDE		SPIN RATE (DEG /SEC)	BEGIN	E N D		DROPOUTS, MINUTES W/R/T AND		
		EARTH LONGI (DEG)	MINUTES (GMT)	CALENDAR DATE	HOURS		DECLI -NATION (DEG)	RIGHT ASCEN -SION (DEG)	MINI -MUM NADIR (DEG)	TOT (MIN. AFTER AND)			HOURS MINUTES SECONDS (GMT)	MINU W/R/T AND	MINU -TES W/R/T AND	FROM- TO-	
1050	1	-84.07	10*26*31	8/29/63	71	29.2	132.3	28.6	22.3	54.028	-85.8	10*36*3	9.5	405			
1051	1	-108.74	12*3*56	8/29/63	71	29.2	132.4	28.6	22.4	54.022	-77.2	12*16*3	12.1	405			
1052	1	-133.41	13*41*20	8/29/63	71	29.2	132.4	28.7	22.5	54.017	-75.3	13*49*3	7.7	405			
1053	2	-158.69	15*18*45	9/29/63	71	29.2	132.5	28.7	22.5	54.012	-79.6	15*31*3	12.3	405			
1055	1	152.55	18*33*34	8/29/63	71	29.1	132.6	28.8	22.7	54.001	-62.3	19*6*33	33.0	405			
1058	2	78.53	23*25*48	8/23/63	71	29.0	132.6	29.0	22.9	53.984	-52.7	0*3*33	37.8	405			
1065	1	-94.17	10*47*40	8/30/63	72	28.9	132.3	29.2	23.3	53.946	-28.0	10*58*3	10.4	406			
1066	1	-118.84	12*25*4	8/30/63	72	28.9	132.4	29.2	23.4	53.941	-74.8	12*39*3	14.0	406			
1067	2	-143.51	14*2*29	8/30/63	72	28.9	132.4	29.2	23.5	53.935	-73.3	14*11*3	8.6	406			
1072	2	93.11	22*9*32	9/30/63	72	28.8	132.6	29.4	23.9	53.908	-38.9	22*44*3	34.5	406			
1080	1	-104.27	11*8*49	8/31/63	73	28.8	132.4	29.5	24.4	53.865	-81.1	11*19*33	10.7	407			
1081	2	-128.94	12*46*13	8/31/63	73	28.8	132.4	29.5	24.5	53.859	-75.5	12*54*3	7.8	407			
1082	2	-153.62	14*23*38	8/31/63	73	28.8	132.5	29.4	24.6	53.854	-79.5	14*35*3	11.4	407			
1084	1	157.13	17*38*27	8/31/63	73	28.8	132.6	29.4	24.6	53.843	-60.9	18*10*3	31.6	407			
1087	2	33.01	22*30*41	8/31/63	73	28.6	132.6	29.5	24.9	53.827	-55.7	23*8*33	37.9	407			
1094	1	-89.71	9*52*33	9/1/63	74	28.7	132.3	29.4	25.3	53.789	-84.6	10*2*3	9.5	408			
1095	1	-114.37	11*29*57	9/1/63	74	28.7	132.4	29.4	25.4	53.784	-76.1	11*43*3	13.1	408			
1096	2	-139.64	13*7*22	9/1/63	74	28.7	132.4	29.3	25.4	53.779	-72.1	13*17*3	9.7	408			
1099	1	146.92	17*59*36	9/1/63	74	28.7	132.6	29.3	25.7	53.763	-16.5	18*33*3	33.5	408			
1101	2	97.58	21*14*25	9/1/63	74	28.7	132.6	29.3	25.9	53.752	-51.1	21*52*3	37.6	408			
1109	1	-99.60	10*13*42	9/2/63	75	28.8	132.3	29.0	25.3	53.709	-71.7	10*24*3	10.4	409			
1110	2	-124.47	11*51*6	9/2/63	75	28.8	132.3	29.0	25.4	53.704	-74.7	11*58*3	7.0	409			
1111	2	-149.15	13*28*31	9/2/63	75	28.8	132.4	28.9	26.5	53.698	-80.0	13*39*3	10.5	409			
1113	1	161.50	16*43*20	9/2/63	75	28.8	132.5	28.8	25.7	53.688	-62.9	17*15*3	31.7	409			
1116	2	87.42	21*35*34	9/2/63	75	28.8	132.7	28.7	25.9	53.672	-53.3	22*14*33	39.0	409			

ORBIT NO.	CDA STA	READOUT				ORBIT				TIME INTERVAL OF FILE ON FMR TAPE						FMR TAPE REEL NO.		
		SATELLITE ORBITAL		EQUATOR CROSSING AT		SPIN	VECTOR	ATTITUDE		BEGIN	E N D			DROPOUTS, MINUTES W/R/T AND				
		EARTH LONGI- TUD E (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TIROS DAY			DECLI- NATION (DEG)	RIGHT ASCEN- SION (DEG)		MINI- MUM NAIR (DEG)	TOT (MIN. AFTER AND)	SPIN RATE (DEG /SEC)	MINU- TES W/R/T AND	HOURS MINUTES SECONDS (GMT)		MINU- TES W/R/T AND	TO- FROM-
1123	1	-85.22	8*57*26	9/ 3/63	76	28.5	133.5	28.5	27.6	53.634	-83.8	9* 7* 3	9.6	410				
1124	1	-109.89	10*34*50	9/ 3/63	76	28.4	133.6	28.5	27.7	53.629	-75.9	10*47* 3	12.2	410				
1125	2	-134.57	12*12*15	9/ 3/63	76	28.4	133.7	28.5	27.8	53.624	-57.4	12*21* 3	8.8	410				
1126	2	-159.24	13*49*40	9/ 3/63	76	28.4	133.8	28.5	27.9	53.618	-78.0	14* 2* 3	12.4	410				
1128	1	151.40	17* 4*29	9/ 3/63	76	28.3	133.9	28.4	28.1	53.608	-61.5	17*37*27	33.0	410				
1130	2	102.16	20*19*18	9/ 3/63	76	28.2	134.1	28.3	28.2	53.597	-41.2	20*56*33	37.3	410				
1138	1	-95.32	9*18*34	9/ 4/63	77	27.8	135.0	28.0	29.0	53.554	-74.0	9*29* 3	10.5	411				
1139	1	-119.99	10*55*59	9/ 4/63	77	27.7	135.1	28.0	29.1	53.549	-11.0	11*10* 3	14.1	411				
1140	2	-144.67	12*33*24	9/ 4/63	77	27.7	135.1	28.0	29.2	53.544	-73.2	12*42*33	9.2	411				
1142	1	165.98	15*48*13	9/ 4/63	77	27.6	135.3	27.9	29.4	53.533	-65.2	16*18*33	30.3	411				
1143	1	141.31	17*25*37	9/ 4/63	77	27.5	135.4	27.8	29.5	53.528	-13.6	17*58*33	32.9	411				
1145	2	91.96	20*40*27	9/ 4/63	77	27.5	135.6	27.7	29.7	53.517	-41.5	21*17*33	37.1	411				
1152	1	-80.74	8* 2*19	9/ 5/63	78	26.7	136.6	27.5	30.5	53.480	-86.5	8*12* 3	9.7	412				
1153	1	-105.42	9*39*43	9/ 5/63	78	26.6	136.7	27.5	30.6	53.474	-23.4	9*50*33	10.8	412				
1154	2	-130.09	11*17* 8	9/ 5/63	78	26.4	136.8	27.5	30.7	53.469	-37.6	11*25* 3	7.9	412				
1155	2	-154.76	12*54*32	9/ 5/63	78	26.3	136.9	27.5	30.8	53.464	-78.7	13* 6* 3	11.5	412				
1157	1	155.88	16* 9*22	9/ 5/63	78	26.1	137.0	27.4	30.9	53.453	-61.7	16*41*33	32.2	412				
1159	2	106.53	19*24*11	9/ 5/63	78	26.0	137.3	27.3	31.1	53.442	-40.3	19*59* 3	34.9	412				
1160	2	81.86	21* 1*35	9/ 5/63	78	25.9	137.4	27.3	31.2	53.437	-49.0	21*41*58	40.4	412				
1167	1	-90.84	8*23*27	9/ 6/63	79	24.8	138.5	27.0	32.1	53.399	-82.4	8*33* 3	9.6	413				
1169	2	-140.19	11*38*16	9/ 6/63	79	24.5	138.7	27.0	32.3	53.389	-74.0	11*46*33	8.3	413				
1172	1	145.78	16*30*30	9/ 6/63	79	24.2	138.8	26.9	32.5	53.373	-59.6	17* 4* 3	33.6	413				
1174	2	96.43	19*45*19	9/ 6/63	79	24.0	139.1	26.8	32.8	53.362	-39.4	20*22* 3	36.7	413				
1182	2	-100.94	8*44*36	9/ 7/63	80	22.6	140.2	26.4	33.8	53.319	-73.6	8*55* 3	10.5	414				
1193	2	-125.62	10*22* 1	9/ 7/63	80	22.5	140.2	26.4	33.9	53.313	-74.7	10*29* 3	7.0	414				

READOUT										ORBIT					TIME INTERVAL OF FILE ON FMR TAPE							FMR TAPE REEL NO.
ORBIT NO.	CDA STA	SATELLITE ORBITAL		EQUATOR CROSSING AT		SPIN VECTOR		ATTITUDE		SPIN RATE (DEG /SEC)	BEGIN MINU- TES W/R/T AND	E N D			DROPOUTS, MINUTES W/R/T AND							
		EARTH LONGI- TUDINE (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TIROS DAY	DECLI- NATION (DEG)	RIGHT ASCEN- SION (DEG)	MINI- MUM NADIR (DEG)	TOT (MIN. AFTER AND)			HOURS MINUTES SECONDS (GMT)	MINU- TES W/R/T AND	FROM-	TO-							
1184	2	-150.29	11*59*25	9/ 7/63	80	22.3	140.2	26.4	34.0	53.308	-61.9	12*10*33	11.1				414					
1186	2	160.36	15*14*14	9/ 7/63	80	22.0	140.3	26.4	34.2	53.297	-63.0	15*45*55	31.7				414					
1188	2	111.61	18*29* 4	9/ 7/63	80	21.8	140.5	26.3	34.3	53.286	-43.2	19* 3* 3	34.0				414					
1189	2	86.33	20* 6*28	9/ 7/63	80	21.7	140.6	26.2	34.4	53.281	-51.3	20*44* 3	37.6				414					
1196	2	-86.37	7*28*20	9/ 8/63	81	20.3	141.5	25.8	35.3	53.243	-85.7	7*38* 3	9.7				415					
1197	2	-111.64	9* 5*45	9/ 8/63	81	20.1	141.5	25.9	35.4	53.238	-76.6	9*18* 3	12.3				415					
1198	2	-135.72	10*43* 9	9/ 8/63	81	19.9	141.5	25.8	35.4	53.232	-74.1	10*52*27	9.3				415					
1199	2	-160.39	12*20*34	9/ 8/63	81	19.7	141.5	25.8	35.5	53.227	-77.0	12*33*33	13.0				415					
1201	2	150.25	15*35*23	9/ 8/63	81	19.5	141.6	25.7	35.7	53.216	-61.3	16* 8*33	33.2				415					
1203	2	100.91	18*50*12	9/ 8/63	81	19.2	141.7	25.6	35.9	53.205	-41.7	19*25* 3	34.9				415					
1211	1	-96.47	7*49*29	9/ 9/63	82	17.7	142.3	25.1	36.8	53.162	-76.6	8* 0* 3	10.6				416					
1212	1	-121.14	9*26*53	9/ 9/63	82	17.5	142.3	25.0	35.9	53.156	-75.1	9*41* 3	14.2				416					
1213	2	-145.82	11* 4*18	9/ 9/63	82	17.4	142.3	25.0	37.0	53.151	-72.4	11*14*33	10.3				416					
1215	1	164.83	14*19* 7	9/ 9/63	82	17.1	142.3	24.9	37.2	53.140	-63.5	14*49*33	30.4				416					
1216	1	140.16	15*56*32	9/ 9/63	82	17.0	142.3	24.8	37.2	53.134	-54.6	16*31* 3	34.5				416					
1218	2	90.81	19*11*21	9/ 9/63	82	16.8	142.3	24.7	37.3	53.123	-57.3	19*47*28	36.1				416					
1225	1	-81.92	6*33*13	9/10/63	83	15.7	142.5	24.2	38.0	53.085	-88.8	6*42*33	9.3				417					
1226	1	-106.59	8*10*38	9/10/63	83	15.5	142.5	24.1	38.1	53.079	-75.2	8*21* 3	10.4				417					
1230	3	154.71	14*40*16	9/10/63	83	15.0	142.5	23.9	38.4	53.057	-24.2	14*59*33	19.3				417					
1231	1	130.63	16*17*40	9/10/63	83	14.9	142.4	23.8	38.5	53.052	-67.8	16*53* 3	35.4				417					
1233	2	80.69	19*32*30	9/10/63	83	14.6	142.5	23.6	38.6	53.041	-66.6	20*10* 3	37.6				417					
1241	1	-116.69	8*31*46	9/11/63	84	13.3	142.6	23.0	39.3	52.996	-70.9	8*45* 3	13.3				418					
1242	2	-141.36	10* 9*11	9/11/63	84	13.1	142.6	23.0	39.4	52.991	-71.9	10*17*33	8.4				418					
1244	1	169.28	13*24* 0	9/11/63	84	12.8	142.5	22.9	39.6	52.980	-63.7	13*54* 3	30.1				418					
1245	3	144.61	15* 1*25	9/11/63	84	12.7	142.5	22.8	39.7	52.974	-57.0	15*22* 3	20.6				418					

READOUT										ORBIT					TIME INTERVAL OF FILE ON FMR TAPE										FMR TAPE REEL NO.								
ORBIT NO.	CDA STA	SATELLITE EQUATOR CROSSING AT (ANO)			SPIN VECTOR ATTITUDE			SPIN RATE (DEG /SEC)	BEGIN	E N D			DROPOUTS, MINUTES																				
		ORBITAL		TIROS	DECLI -NA (DEG)	RIGHT ASCEN -SION (DEG)	MINI -MUM NADIR (DEG)			TOT (MIN. AND)	HOURS MINUTES SECONDS (GMT)	MINU -TES W/R/T AND	FROM- TO-																				
		EARTH LONGI -TUDE (DEG)	HOURS MINUTES SECONDS (GMT)											CALENDAR DATE	DAY																		
1246	3	119.94	16*38*49		9/11/63	84	12.6	142.4	22.7	39.7	52.968	-64.9	17* 2* 3	23.2																		418	
1255	1	-102.11	7*15*30		9/12/63	85	11.2	142.7	21.8	40.5	52.918	-76.2	7*25*58	10.5																			419
1256	1	-126.79	8*52*55		9/12/63	85	11.0	142.8	21.7	40.6	52.912	-74.6	9* 8*28	15.6																			419
1259	3	159.19	13*45* 9		9/12/63	85	10.6	142.8	21.4	40.9	52.895	-50.1	14* 4* 3	18.9																			419
1262	2	85.17	18*37*22		9/12/63	85	10.5	142.9	21.0	41.0	52.878	-50.3	19*16* 3	38.7																			419
1269	1	-87.54	5*59*14		9/13/63	86	10.7	143.2	19.3	41.4	52.838	-84.5	6* 9* 3	9.8																			420
1270	1	-112.21	7*36*39		9/13/63	86	10.7	143.2	19.0	41.4	52.833	-75.9	7*49* 3	12.4																			420
1272	2	-161.56	10*51*28		9/13/63	86	10.8	143.4	18.5	41.5	52.821	-82.6	11* 4*28	13.0																			420
1276	2	99.74	17*21* 6		9/13/63	86	10.9	143.6	17.5	41.7	52.798	-62.5	17*56* 3	35.0																			420
1284	1	-97.64	6*20*23		9/14/63	87	11.2	143.8	15.5	42.0	52.752	-76.6	6*31* 3	10.7																			421
1285	1	-122.31	7*57*47		9/14/63	87	11.2	143.9	15.3	42.1	52.746	-75.7	8*12* 3	14.3																			421
1286	2	-146.98	9*35*12		9/14/63	87	11.3	143.9	15.0	42.1	52.740	-73.2	9*45*28	10.3																			421
1289	3	138.99	14*27*26		9/14/63	87	11.3	144.1	14.2	42.3	52.723	-54.2	14*49*28	22.0																			421
1291	2	89.64	17*42*15		9/14/63	87	11.4	144.2	13.7	42.3	52.714	-52.8	18*18*28	36.2																			421
1298	1	-83.06	5* 4* 7		9/15/63	88	11.8	144.3	12.0	42.6	52.673	-88.3	5*13*28	9.4																			422
1299	1	-107.73	6*41*31		9/15/63	88	11.8	144.4	11.7	42.6	52.668	-76.6	6*53* 3	11.5																			422
1300	2	-132.41	8*18*56		9/15/63	88	11.8	144.4	11.5	42.7	52.662	-76.3	8*27* 3	8.1																			422
1301	2	-157.18	9*56*21		9/15/63	88	11.9	144.5	11.2	42.7	52.656	-74.2	10* 8*28	12.1																			422
1303	3	153.56	13*11*10		9/15/63	88	11.9	144.6	10.7	42.7	52.644	-63.9	13*31* 3	19.9																			422
1304	3	128.89	14*48*34		9/15/63	88	12.0	144.6	10.4	42.8	52.639	-66.8	15*11* 3	22.5																			422
1306	2	79.54	18* 3*23		9/15/63	88	12.1	144.7	9.9	42.9	52.627	-56.2	18*41* 3	37.7																			422
1313	1	-93.16	5*25*15		9/16/63	89	12.5	144.8	8.2	43.1	52.586	-84.8	5*35* 3	9.8																			423
1314	1	-117.83	7* 2*40		9/16/63	89	12.5	144.8	7.9	43.1	52.580	-75.6	7*16* 3	13.4																			423
1315	2	-142.51	8*40* 5		9/16/63	89	12.6	144.9	7.6	43.1	52.574	-71.1	8*49* 3	9.0																			423
1318	3	143.46	13*32*18		9/16/63	89	12.7	145.0	6.8	43.3	52.557	-60.2	13*53* 3	20.8																			423

ORBIT NO.	ORBIT	REACOUT										ORBIT										TIME INTERVAL OF FILE ON FMR TAPE				FMR TAPE REEL NO.
		GDA STA	SATELLITE ORBITAL		EQUATOR CROSSING AT		SPIN		VECTOR		ATTITUDE		BEGIN	E N D		DROPOUTS, MINUTES										
			EARTH LONGI (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TITROS DAY	DECLI -NA -TION (DEG)	RIGHT ASCEN -SION (DEG)	MINI -MUM -NADIR (DEG)	TOT (MIN. AFTER AND)	SPIN RATE (DEG /SEC)	MINU -TES W/R/T AND		HOURS MINUTES SECONDS (GMT)	MINU -TES W/R/T AND	FROM- TO-										
1328	1	-103.28	5*46*24	9/17/63	90	13.4	145.2	4.3	43.5	52.498	-78.9	5*56*33	10.2					424								
1329	2	-127.96	7*23*49	9/17/63	90	13.4	145.2	4.0	43.6	52.492	-73.8	7*31*3	7.2					424								
1330	2	-152.63	9*1*13	9/17/63	90	13.5	145.3	3.8	43.6	52.486	-79.3	9*12*3	10.8					424								
1332	3	158.01	12*16*2	9/17/63	90	13.6	145.3	3.2	43.7	52.475	-64.9	12*35*3	19.0					424								
1333	3	133.34	13*53*27	9/17/63	90	13.6	145.4	3.0	43.7	52.469	-68.5	14*15*3	21.6					424								
1335	2	83.99	17*8*16	9/17/63	90	13.8	145.4	2.5	43.7	52.457	-57.2	17*45*3	36.8					424								
1343	1	-113.39	6*7*32	9/18/63	91	14.4	145.5	0.4	44.0	52.410	-76.8	6*20*3	12.5					425								
1344	2	-138.06	7*44*57	9/18/63	91	14.5	145.5	-0.1	43.9	52.404	-73.7	7*55*0	10.1					425								
1345	2	-162.73	9*22*22	9/18/63	91	14.5	145.6	-0.2	43.9	52.398	-77.6	9*35*3	12.7					425								
1348	3	123.24	14*14*35	9/18/63	91	14.7	145.7	-1.0	44.0	52.380	-70.7	14*38*3	23.5					425								
1357	1	-98.81	4*51*16	9/19/63	92	14.4	145.8	-2.8	44.4	52.327	-76.3	5*1*3	9.8					426								
1358	1	-123.48	6*28*41	9/19/63	92	14.4	145.8	-3.1	44.5	52.321	-75.4	6*43*3	14.4					426								
1359	2	-148.16	8*6*5	9/19/63	92	14.4	145.8	-3.3	44.5	52.315	-72.5	8*16*3	10.0					426								
1362	3	137.81	12*58*19	9/19/63	92	14.3	145.8	-3.9	44.7	52.297	-59.4	13*20*3	21.7					426								
1363	2	113.14	14*35*44	9/19/63	92	14.3	145.9	-4.1	44.7	52.291	-64.8	15*11*3	35.3					426								
1364	2	48.46	16*13*8	9/19/63	92	14.3	145.9	-4.3	44.8	52.285	-52.0	16*48*33	35.4					426								
1371	1	-84.24	3*35*0	9/20/63	93	14.1	145.9	-5.7	45.0	52.244	-87.5	3*44*3	9.1					427								
1372	1	-108.91	5*12*25	9/20/63	93	14.1	145.9	-5.9	45.1	52.238	-76.5	5*24*3	11.6					427								
1373	2	-133.58	6*49*49	9/20/63	93	14.1	145.9	-6.1	45.1	52.232	-76.0	6*58*3	8.2					427								
1374	2	-158.26	8*27*14	9/20/63	93	14.1	145.9	-6.3	45.2	52.226	-77.7	8*39*3	11.8					427								
1376	3	152.38	11*42*3	9/20/63	93	14.0	145.9	-6.7	45.2	52.214	-36.6	12*2*3	20.0					427								
1377	3	127.71	13*19*28	9/20/63	93	14.0	145.9	-6.9	45.2	52.208	4.3	13*42*3	22.6					427								
1379	2	78.37	16*34*17	9/20/63	93	14.0	145.9	-7.4	45.3	52.196	-56.7	17*12*3	37.8					427								
1387	1	-119.01	5*33*33	9/21/63	94	13.9	145.9	-8.9	45.6	52.149	-76.2	5*47*3	13.5					428								
1388	2	-143.69	7*10*58	9/21/63	94	13.8	145.8	-9.1	45.6	52.143	-72.3	7*20*3	9.1					428								

ORBIT NO.	CDA STA	READOUT					ORBIT					TIME INTERVAL OF FILE ON FMR TAPE					FMR TAPE REEL NO.
		SATELLITE ORBITAL		EQUATOR CROSSING AT		SPIN	VECTOR	ATTITUDE		SPIN RATE (DEG /SEC)	BEGIN	E N D		DROPOUTS, MINUTES W/R/T AND			
		EARTH LCNCT TUDE (DEG)	ASCENDING (NO.)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE			TIROS DAY	DECLI -NA -TION (DEG)			RIGHT ASCEN -SION (DEG)	MINI -MUM NADIR (DEG)		TOT (MIN. AFTER AND)		
																MINU -TES W/R/T AND	
1390	3	166.96	10*25*47	9/21/63	94	13.8	145.8	-9.5	45.7	52.131	-63.5	10*44*28	18.7	428			
1391	3	142.29	12* 3*11	9/21/63	94	13.8	145.8	-9.7	45.7	52.125	-66.9	12*24* 3	20.9	428			
1393	2	92.94	15*18* 0	9/21/63	94	13.8	145.8	-10.1	45.8	52.113	-55.3	15*53* 3	35.1	428			
1401	1	-104.44	4*17*17	9/22/63	95	13.7	145.8	-11.7	45.1	52.066	-80.9	4*28* 3	10.8	429			
1402	2	-129.11	5*54*41	9/22/63	95	13.7	145.8	-12.0	45.2	52.060	-75.1	6* 4* 3	9.4	429			
1403	2	-153.78	7*32* 6	9/22/63	95	13.7	145.8	-12.2	45.2	52.054	-77.3	7*43* 3	11.0	429			
1408	2	82.84	15*39* 9	9/22/63	95	13.7	146.0	-13.4	45.3	52.024	-56.4	16*16* 3	36.9	429			
1415	1	-89.86	3* 1* 1	9/23/63	96	13.7	146.1	-15.0	45.7	51.982	-85.9	3*10* 3	9.0	430			
1416	1	-114.54	4*38*25	9/23/63	96	13.7	146.1	-15.2	46.7	51.977	-75.3	4*51* 3	12.6	430			
1417	2	-139.21	6*15*50	9/23/63	96	13.7	146.1	-15.4	45.8	51.971	-63.5	6*24* 3	8.2	430			
1418	2	-163.88	7*53*14	9/23/63	96	13.7	146.0	-15.6	46.8	51.965	-77.8	8* 6*33	13.3	430			
1422	2	97.41	14*22*52	9/23/63	96	13.8	146.1	-16.6	45.8	51.941	-53.9	14*58* 3	35.2	430			
1430	1	-99.96	3*22* 9	9/24/63	97	14.1	146.0	-18.4	47.0	51.894	-75.9	3*31* 3	8.9	431			
1431	1	-124.63	4*59*33	9/24/63	97	13.2	145.6	-18.6	47.1	51.888	-77.2	5*15* 3	15.5	431			
1432	2	-149.31	6*36*58	9/24/63	97	12.3	145.1	-18.0	47.3	51.882	-70.2	6*47* 3	10.1	431			
1434	3	161.53	9*51*47	9/24/63	97	10.5	144.1	-16.7	47.7	51.870	-62.0	10*10* 3	18.3	431			
1435	3	136.26	11*29*11	9/24/63	97	9.6	143.7	-16.1	47.8	51.864	10.9	11*51* 3	21.9	431			
1436	2	111.99	13* 6*36	9/24/63	97	8.6	143.5	-15.5	48.1	51.858	-60.9	13*40* 3	33.5	431			
1437	2	87.52	14*44* 1	9/24/63	97	7.4	143.5	-15.0	48.3	51.852	-53.0	15*21* 3	37.0	431			
1444	1	-85.38	2* 5*52	9/25/63	98	-1.1	143.0	-11.8	50.5	51.811	-85.4	2*15* 3	9.2	432			
1445	1	-110.66	3*43*17	9/25/63	98	-2.1	142.6	-11.2	50.8	51.805	-76.2	3*55* 3	11.8	432			
1447	2	-159.41	6*58* 6	9/25/63	98	-4.0	141.8	-9.9	51.2	51.793	-3.1	7*10* 3	12.0	432			
1450	3	126.57	11*50*20	9/25/63	98	-6.7	140.6	-8.0	51.8	51.776	-4.2	12*13* 3	22.7	432			
1461	2	-144.83	5*41*50	9/26/63	99	-19.4	140.2	-2.8	55.0	51.711	0.2	5*51* 3	9.2	433			
1466	2	91.80	13*48*52	9/26/63	99	-24.4	138.9	-0.2	56.0	51.682	-55.3	14*26* 3	37.2	433			

READOUT										ORBIT						TIME INTERVAL OF FILE ON FMR TAPE					
ORBIT NO.	CDA STA	SATELLITE ORBITAL		EQUATOR CROSSING AT		SPIN VECTOR		ATTITUDE		SPIN RATE (DEG /SEC)	BEGIN		END		DROPOUTS, MINUTES W/R/T AND		FMR TAPE REEL NO.				
		EARTH LONGITUDE (DEG)	HOURS MINUTES SECONDS (GMT)	CALENDAR DATE	TIROS DAY	DECLINATION (DEG)	RIGHT ASCENSION (DEG)	MINI-MUM NADIR (DEG)	TOT (MIN. AFTER AND)		MINUTES W/R/T AND	HOURS MINUTES SECONDS (GMT)	MINUTES W/R/T AND	FROM- TO-							
1473	1	-80.91	1*10*44	9/27/63	100	-32.9	140.3	3.7	58.3	51.641	-87.1	1*19*33	8.8				434				
1474	1	-105.58	2*48*9	9/27/63	100	-34.0	140.3	3.4	58.5	51.636	-79.1	2*59*3	10.9				434				
1475	2	-130.25	4*25*33	9/27/63	100	-34.9	140.1	3.8	58.8	51.630	-76.7	4*35*3	9.5				434				
1476	2	-154.92	6*2*58	9/27/63	100	-35.9	140.0	4.3	59.1	51.624	-76.7	6*14*3	11.1				434				
1478	1	155.72	9*17*47	9/27/63	100	-37.6	139.5	5.3	59.5	51.612	-61.9	9*50*3	32.3				434				
1480	2	106.37	12*32*36	9/27/63	100	-39.1	139.3	6.4	59.9	51.601	-54.9	13*7*3	34.5				434				
1481	2	81.70	14*10*1	9/27/63	100	-39.1	139.2	6.5	60.1	51.595	-51.7	14*48*3	38.0				434				
1489	1	-115.68	3*9*18	9/28/63	101	-38.8	139.0	5.2	60.2	51.549	-76.9	3*23*3	13.8				435				
1490	2	-140.35	4*46*40	9/28/63	101	-37.3	138.7	4.4	59.9	51.543	-70.8	4*55*3	8.4				435				
1493	1	145.62	9*38*54	9/28/63	101	-36.9	138.7	3.7	59.9	51.526	-50.8	10*12*3	33.2				435				
1503	1	-101.10	1*52*59	9/29/63	102	-35.0	138.1	1.3	59.8	51.469	-72.2	2*3*3	10.1				436				
1504	1	-125.77	3*30*24	9/29/63	102	-34.9	138.1	1.0	59.8	51.463	-74.4	3*46*3	15.7				436				
1505	2	-150.44	5*7*48	9/29/63	102	-34.7	138.1	0.7	59.8	51.457	-71.0	5*18*3	10.3				436				
1507	1	160.20	8*22*38	9/29/63	102	-34.4	138.2	0.3	59.8	51.446	-62.9	8*54*3	31.4				436				
1508	1	135.53	10*0*2	9/29/63	102	-34.3	138.2	0.1	59.9	51.440	-54.9	10*35*3	35.0				436				
1510	2	86.18	13*14*51	9/29/63	102	-33.9	138.1	-0.5	59.8	51.429	-30.1	13*52*3	37.2				436				
1517	1	-86.53	0*36*43	9/30/63	103	-32.5	137.6	-2.3	59.7	51.389	-78.0	0*46*3	9.3				437				
1518	1	-111.20	2*14*8	9/30/63	103	-32.3	137.6	-2.5	59.7	51.384	-58.8	2*26*3	11.9				437				
1519	2	-135.87	3*51*32	9/30/63	103	-32.2	137.6	-2.8	59.8	51.378	-19.7	4*0*3	8.5				437				
1520	2	-160.54	5*28*57	9/30/63	103	-32.0	137.6	-3.1	59.8	51.372	-78.2	5*42*3	13.1				437				
1522	1	150.10	8*43*46	9/30/63	103	-31.7	137.7	-3.6	59.7	51.361	-60.2	9*16*3	32.3				437				
1523	1	125.43	10*21*10	9/30/63	103	-31.5	137.7	-3.9	59.7	51.356	-54.0	10*58*3	36.9				437				
1524	2	100.75	11*58*35	9/30/63	103	-31.3	137.6	-4.2	59.7	51.350	-50.6	12*34*3	35.5				437				
1525	2	76.08	13*36*0	9/30/63	103	-31.1	137.6	-4.5	59.7	51.344	-51.3	14*15*3	39.1				437				

## APPENDIX B

### SUBPOINT TRACK SUMMARY OF AVAILABLE RADIATION DATA

In this section, the time interval for which radiation data are available on the FMR tapes for TIROS VII from launch, June 19, 1963, to September 30, 1963 is summarized diagrammatically by means of subpoint tracks for each interrogation day. As discussed previously, an interrogation day may be contained within the calendar day, or it may consist of parts of two calendar days. This method of presentation enables the data user to quickly appraise the orbits containing data in an area of interest.

Before discussing the subpoint track summaries, however, the various scanning modes of the TIROS radiometer and the relationship between the satellite nadir angle (the angle between the local vertical and the spin axis in the direction of the television cameras) and the optical axis of the medium resolution radiometer will be illustrated.

The three possible earth scanning patterns, or modes, of the TIROS radiometer may be characterized as follows (Figure B1):

(a) Closed Mode—All scan spots throughout a number of spin cycles of the satellite are earth viewed, either through the wall sensor or the floor sensor.

(b) Single Open Mode—Some scan spots of a spin cycle are space viewed and the remainder are earth viewed through the wall sensor only or through the floor sensor only.

(c) Alternating Open Mode—The scan spots of a spin cycle are a combination of space and earth viewed, alternately through the wall sensor and the floor sensor.

In Figure B2, on an earth cross-section, are shown nominal satellite nadir angle values bounding the various radiometer scanning modes. These values are for a height above the earth of about 635 km. It has been assumed that the spin vector coordinates remain constant throughout one orbit and that the minimum nadir angle is zero. Generally, the minimum nadir angle encountered throughout an orbit is not zero,

hence diminishing the time period of the closed mode. In a number of orbits, the minimum nadir angle is greater than  $20.5^\circ$ , and hence there is no closed mode.

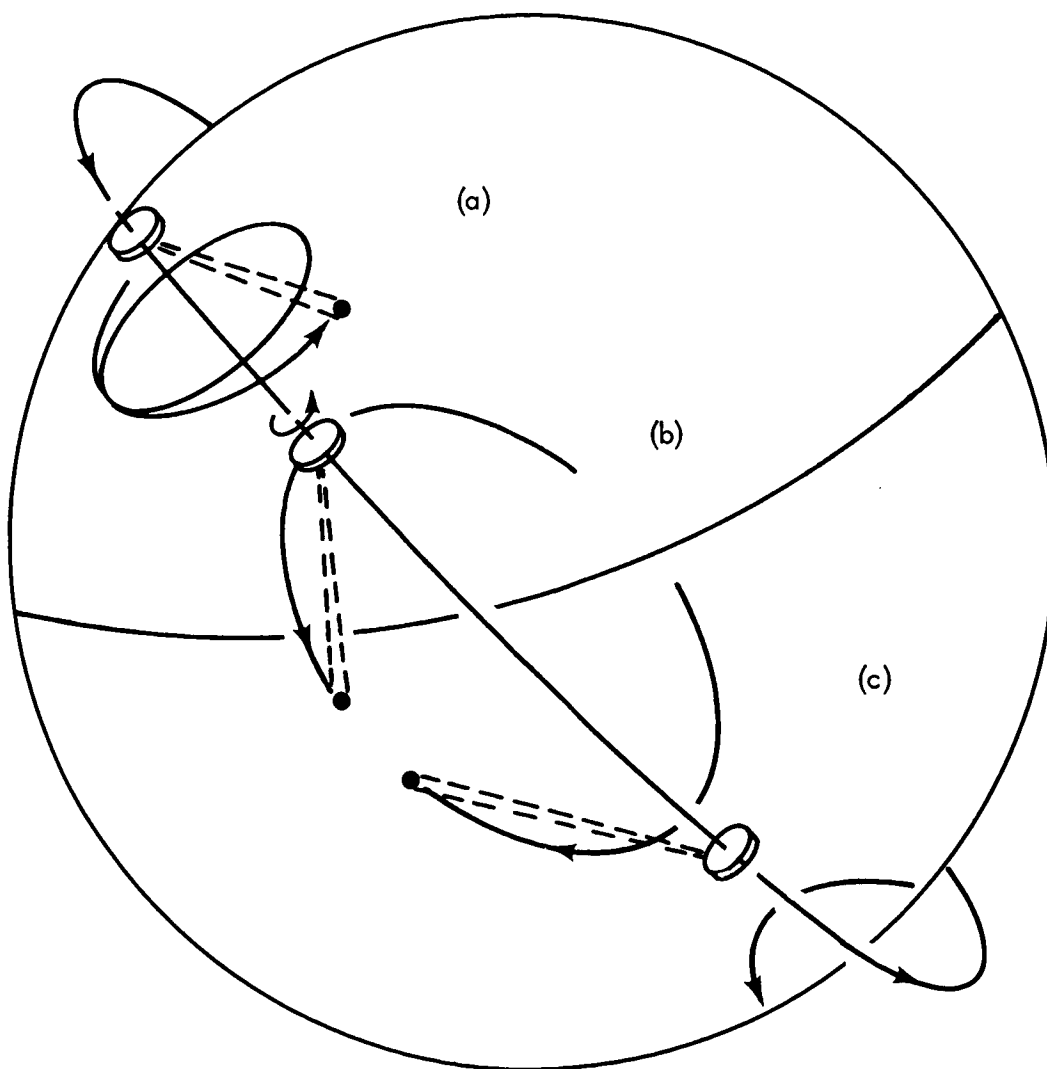
On the subpoint track summaries, each interrogation day is denoted by its calendar date or dates as the case may be. Dropouts are indicated by a symbol  $| - |$  where each dash represents one minute for which data are not available. Dropouts which occur at the beginning of tape have been left off the subpoint summaries. Each orbit is identified by orbit number and the time of occurrence of the ANO, to the hour and nearest minute in GMT. The symbol " $\odot$ " indicates the point with respect to the orbital subpoint track where the minimum satellite nadir ( $\eta_o$ ) angle for the interrogation day occurs and its location is the point at which the spin axis intersects the earth's surface. The orbit to which  $\eta_o$  applies is indicated by a straight line drawn normal to that orbit and the value of  $\eta_o$  to the nearest degree is also indicated. In cases where any ambiguity might arise as to the orbit to which  $\eta_o$  applies, an arrow parallel to the applicable subpoint track is used (e.g. on page 180,  $\eta_o = -19^\circ$  applies to Readout Orbit 427). The spin vector changes only slightly in declination and right ascension during one interrogation day; and, thus, the minimum nadir angle is essentially constant and remains at approximately the same relative position to each orbit during one interrogation day.

To illustrate the use of the subpoint summaries, we use the same example as was used in Appendix A. If the master subpoint track overlay from the back cover of the Catalog-Manual is placed over the subpoint track for orbit 277 (page 170) with the ascending node at longitude  $91.36^\circ$  West, then the subpoint track shown is applicable to the available data acquired during this interrogation. For a limiting scan nadir angle of  $58^\circ$ , the radiometer can acquire data from an area along the subpoint track which is within  $11^\circ$  of great circle arc on either side of the track. It can be seen that the data began 94.2 minutes before and ended 10.6 minutes after the ascending node time which



was approximately 03:28 GMT. Also, a one minute dropout occurs between -54.4 and -53.4 minutes with respect to the ascending node time. The minimum satellite nadir angle to the nearest whole degree, and sufficiently accurate to apply to the entire interrogation day, was  $-30^{\circ}$  on orbit 279. The intersection of the spin (camera) axis with the earth, indicated by an "⊙", lay south of the subpoint track as indicated by the negative value of the minimum satellite nadir angle.

The bounding orbits of periods where there exists direct solar radiation interference in the reduced channel 3 and 5 data (as described in Section VI) are given in the lower right hand corner of the Subpoint Track Summaries for the period in which they apply. For example, direct solar radiation interference in channels 3 and 5 on all orbits from 0321 to 0343 inclusive is indicated on the Subpoint Track Summaries for the days July 11 and 12, 1963.



*Figure B1*—Scanning modes of the TIROS radiometer: (a) closed mode, (b) single open mode, and (c) alternating open mode.

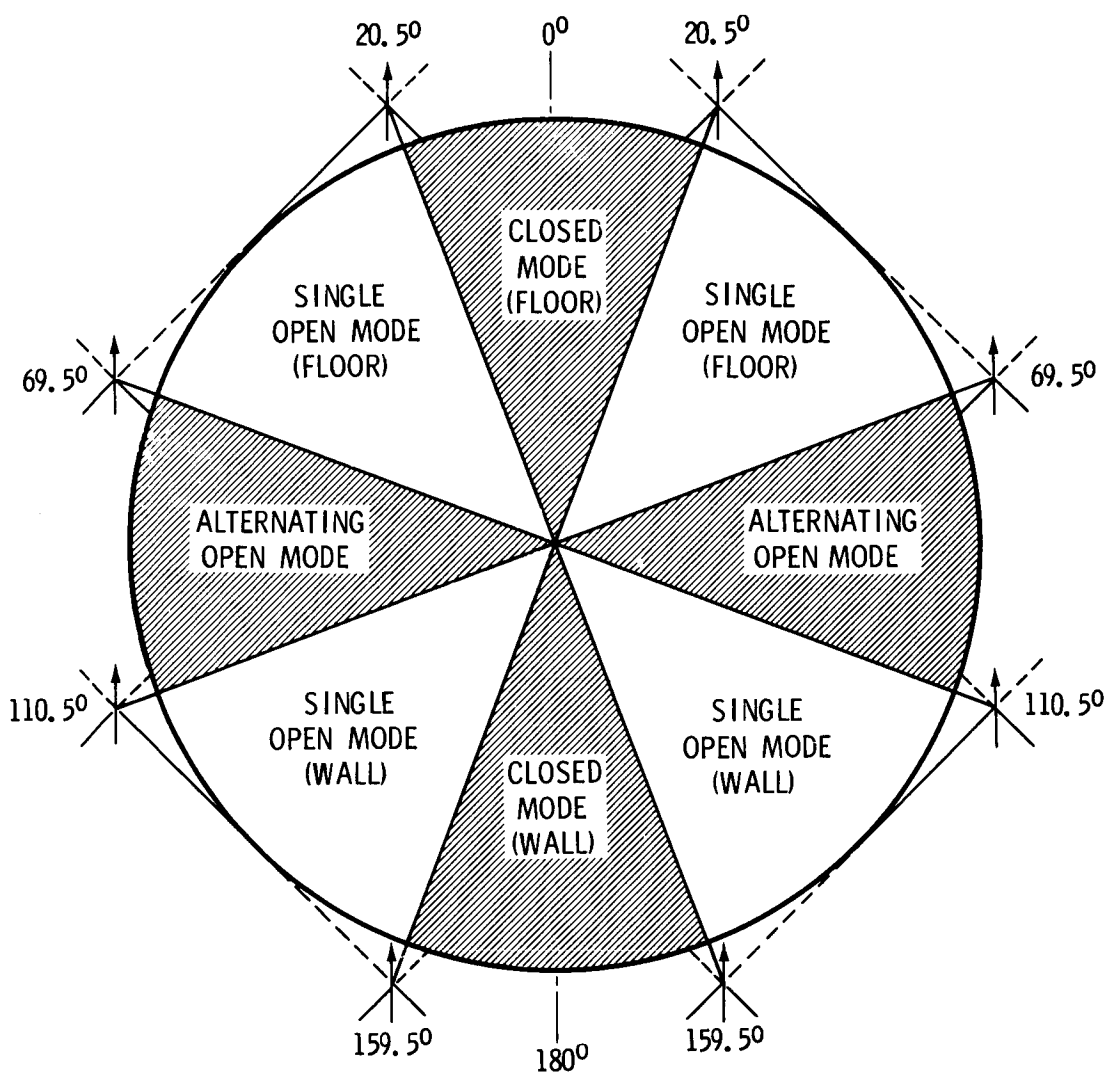


Figure B2—Nominal boundary satellite nadir angles for the various scanning modes at a height of about 635 km. Arrows indicate the spin vector through the top of the satellite, and the nadir angles refer to the opposite direction, viz., the spin (camera) axis. Solid lines at 45° to the arrows indicate the floor and dashed lines the wall scans of the radiometer.

